SCIENCE-X

MODULE - 7

INDEX

LIGHT

WHAT IS LIGHT?

If we enter a dark room, the objects present in the room are not visible. However, if we switch on a bulb, everything in the room becomes visible. Why?

The bulb gives out an invisible energy called light. When this energy falls on the objects in the room, it bounces off from the surface of objects. When this energy enters our eyes, the eyes sense it and send a message to the brain. It is finally, the brain which really sees the objects. Eyes are only an aid in seeing the objects around us.

Why do we say that light is invisible ? Well, when light energy falls on the objects, we really do not see it. When energy bounces off from the surface of objects and enters our eyes, the sensation produced by this energy, helps our brain to see. Thus, to sum up we can say.

Light is an invisible energy, which causes in us the sensation of vision. When the light falls on any object, it bounces off from the surface of the object in all directions. This is called scattering of light.

DEFINITION

Light is form of energy which enables us to see objects which emit or reflect light.

Light is a type of (form of) energy which can produce sensation in our eyes. So we can experience the sensation of vision.

It travel in straight line in form of particles and waves. With the help of light we see all colours of nature.

Our eyes are mostly sensitive for yellow colour and least sensitive for violet and red colour. Due to this reason commercial vehicle's are painted with yellow colour, sodium lamps are used in road lights.

OPTICS

It is a branch of physics which deals with the study of light. It is mainly divided into three parts :

(a) **Geometrical optics or ray optics:** It deals with the reflection and refraction of light.

(b) **Wave or physical optics :** It is concerned with nature of light and deals with interference, diffraction and polarisation.

(c) **Quantum optics:** It deals with the interaction of light with the atomic entities of matter such as photo electric effect, atomic excitation etc.

NATURE OF LIGHT

Theories about nature of light :

(a) **Particle Nature of Light (Newton's corpuscular theory) :**

According to Newton light travels in space with a great speed as a stream of very small particles called corpuscles.

According to this theory reflection and refraction of light are explained while this theory was failed to explain interference of light and diffraction of light. So wave theory of light was discovered.

(b) **Wave Nature of Light:**

Huygen consider the light remains in the form of mechanical rays and he consider a hypothetical medium like ether for propagation of light waves:

So, light waves are declared electromagnetic waves so there is no need of medium for the propagation of these waves. They can travel in vacuum also. The speed of these waves in air or in vacuum is maximum i.e., 3×10^8 m/s.

Photoelectric effect was not explained with the help of wave theory, so Planck gave a new theory which was known as quantum theory of light.

This theory is failed to explain photo electric effect.

(c) Quantum Theory of Light:

According to 'Planck' light travels in the form of energy packets or quanta's of energy called photons. The rest mass of photon is zero . Each quanta carries energy **E =hν.**

h $\rightarrow$ Planck's constant = 6.6 x 10^{-34} J-s.

$\nu \rightarrow$ frequency of light

Some phenomenons like interference of light, diffraction of light are explained with the help of wave theory but wave theory was failed to explain the photo electric effect of light. It was explained with the help of quantum theory. So, light has dual nature.

(d) Dual Nature of Light:

De Broglie explained the dual nature of light, i.e wave nature and particle nature.

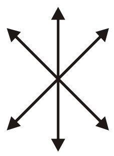
(i) wave nature: Light is electromagnetic waves it is transverse in nature and propagate in **vacuum**
(ii) Particle or Photon Nature : With the help of this theory Einstein explained the photo electric effect.

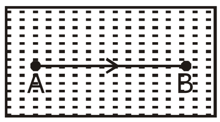
Newton's Thought

Ray of Light

Let us consider a source of lights(s). Also consider the light which passes from the point A to the B in medium.

Actually, the light passes through all the points of the straight line AB. Such a straight line path is called a ray of light, generally represented by a directed arrow ($\longrightarrow$).

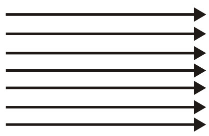




AB is ray of light in a medium

Beam of Light

A bundle of light ray is called a beam of light. The following figure shows a parallel beam of light.


A parallel beam of light

SOURCE OF LIGHT

A body which emits light or reflect the light falling on it in all possible direction is said to be the source of light. The source can be point one or an extended one. The sources of light are of two types :

(a) Luminous Source :

Any object which by itself emits light is called as a luminous source.

e.g.: Sun and stars (natural luminous sources), electric lamps, candles and lanterns (artificial luminous sources).

(b) Non-luminous Source :

Those objects which do not emit light but become visible only when light from luminous objects falls on them. They are called non-luminous sources.

e.g.: Moon, planets (natural non-luminous sources), wood, table (artificial non-luminous sources).

MEDIUM OF LIGHT

Substance through which light propagates or tends to propagate is called medium of light.

(i) Transparent Object :

Bodies that allow light to be pass through them i.e. transmit light through them, are called transparent bodies.

e.g.: Glass, water, air etc.

(ii) Translucent Object :

Bodies that can transmit only a part of light through them are called translucent objects.

e.g.: Frosted or ground glass, greased paper, paraffin wax.

(iii) Opaque Object :

Bodies that do not allow light to pass through them at all are said to be opaque object.

Eg. Chair, desk etc.

NOTE : Depending on composition optical medium are divided into two type.

(i) Homogeneous medium : An optical medium which has a uniform composition throughout is called homogeneous medium.

E.g. Vacuum, distilled water, pure alcohol, glass, plastics, diamond, etc.

(ii) Heterogeneous medium : An optical medium which has different composition at different points is called heterogeneous medium.

Eg. Air, muddy water, fog, mist, etc.

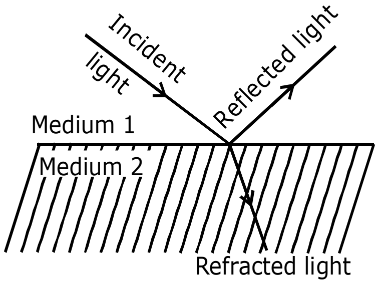
BEHAVIOUR OF LIGHT AT THE INTERFACE OF TWO MEDIA

When light travelling in one medium falls on the surface of a second medium the following three effects may occur :

(i) A part of the incident light is turned back into the first medium. This is called reflection of light.

(ii) A part of the incident light is transmitted into the second medium along a changed direction. This is called refraction of light.

(iii) The remaining third part of light energy is absorbed by the second medium. This is called absorption of light.



CHARACTERISTICS OF LIGHT

Some common characteristics of light are given below :

(i) Light has dual nature i.e both wave and particle, nature.

(ii) Light is an electromagnetic wave.

(iii) Light does not require material medium for its propagation i.e. light can travel through vacuum.

(iv) The speed of light in free space (vacuum) is 3×10^8 m/s. Its speed is marginally less in air. Its speed decreases considerably in glass or water.

(v) Light undergoes reflection from polished surfaces such as mirrors, etc.

(vi) Light undergoes refraction when it goes from one medium to another.

RAY OPTICS

Ray optics treats propagation of light in terms of rays and is valid only if the size of the obstacle is much greater than the wavelength of light. It concern with the image formation and deals with the study of the simply facts such as rectilinear propagation, laws of reflection and refraction by geometrical methods.

Ray :

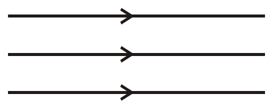
A ray can be defined as an imaginary line drawn in the direction in which light is travelling. Light behaves as a stream of energy propagated along the direction of rays. The rays are directed outward from the source of light in straight lines.

Beam of Light :

A beam of light is a collection of these rays. There are mainly three types of beams.

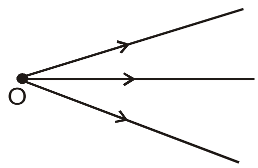
(i) Parallel beam of Light :

A search light and the headlight of a vehicle emit a parallel beam of light. The source of light at a very large distance like sun effectively gives a parallel beam.



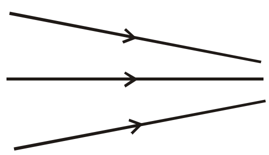
(ii) Divergent beam of Light :

The rays going out from a point source generally form a divergent beam.



(iii) Convergent beam of Light :

A beam of light that is going to meet (or converge) at a point is known as a convergent beam. A parallel beam of light after passing through a convex lens becomes a convergent beam.



HOW WE SEE ?

When a light ray is falling (strike) on the surface of any object which reflect and reached to our eyes. Due to this our eyes feel a sensation then we see the object.

REFLECTION OF LIGHT

When rays of light falls on any object it return back in the same medium from the surface this phenomenon is called reflection of light. Due to reflection of light we can see all the nature.

⇒ **INCIDENT RAY**

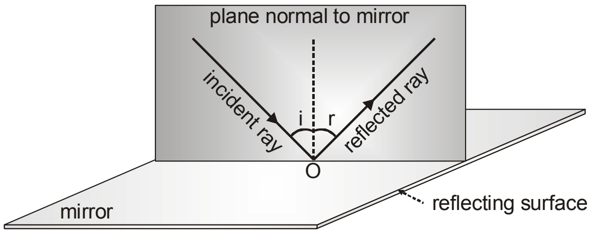
The ray of light which falls on a polished surface (or a mirror) is called the incident ray of light.

⇒ **REFLECTED RAY**

The ray of light which gets reflected from a polished surface (or a mirror) is called the reflected ray of light.

⇒ **NORMAL**

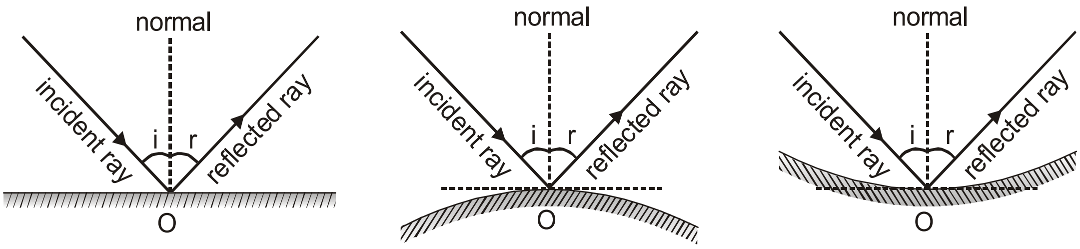
The normal is a line at right angle to the reflecting surface.



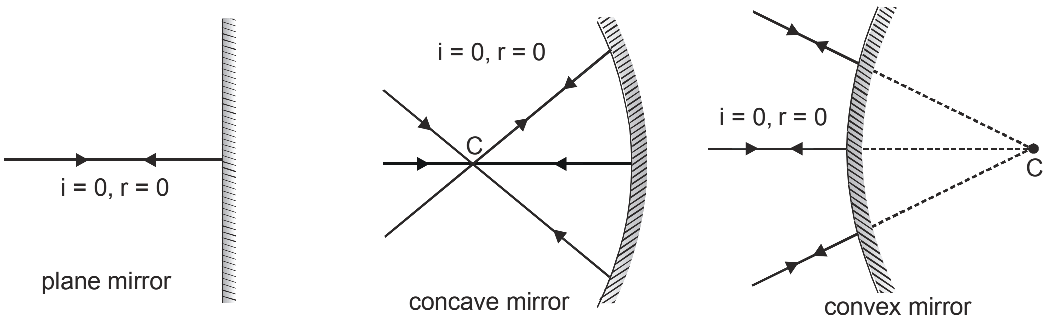
LAWS OF REFLECTION

(i) The incident ray, the reflected ray and the normal to the surface at the point of incidence all lie in the same plane.

(ii) The angle of incidence ($\angle i$) is always equal to the angle of reflection ($\angle r$) i.e. $\angle i = \angle r$



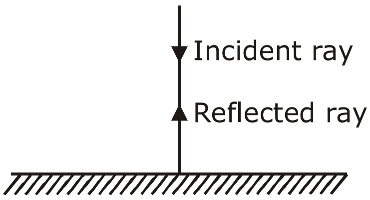
When a ray of light falls on a mirror normally or at right angle it gets reflected back along the same path.



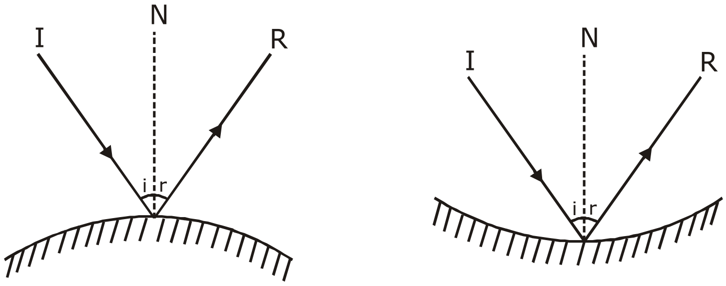
(i) A ray of light striking the surface normally retraces its path.

Explanation

When a ray of light strikes a surface normally, then angle of incidence is zero i.e. $\angle i = 0$. According to the law of reflection, $\angle r = \angle i$, $\therefore$ $\angle r = 0$ i.e. the reflected ray is also perpendicular to the surface. Thus an incident ray normal to the surface (i.e. perpendicular to the surface) retraces its path as shown in figure.



(ii) Laws of reflection are also obeyed when light is reflected from the spherical or curved surface as shown in figure (a) and (b)



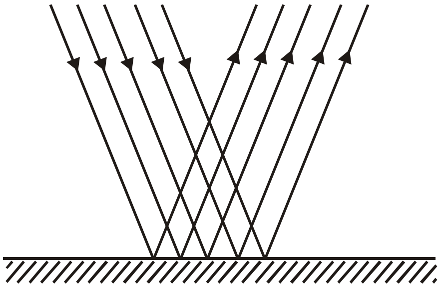
(a) (b)

Depending on the nature of the reflecting surface there are two types of reflection :-

(i) Regular (specular) reflection (ii) Irregular (diffused) reflection

◈ Regular reflection :

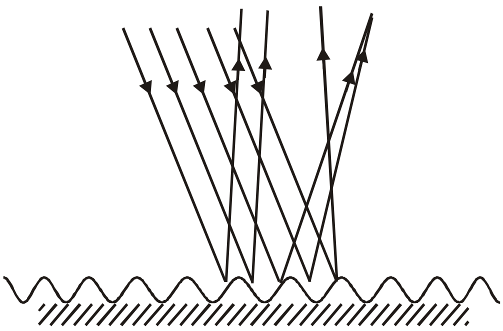
The phenomenon due to which a parallel beam of light travelling through a certain medium, on striking become parallel beam, in some other fixed direction is called Regular reflection.



Regular reflection takes place from the objects like looking glass, still water, oil, highly polished metals etc.

Regular reflection is useful in the formation of images, e.g., we can see our face in a mirror only on account of regular reflection. However, it causes a very strong glare in our eyes.

◈ Irregular reflection or Diffused reflection :



The phenomenon due to which a parallel beam of light, travelling through some medium, gets reflected in various possible directions, on striking some rough surface is called irregular reflection or diffused reflection.

The reflection which takes places from ground, walls, trees, suspended particles in air, and a variety of other objects, which are not very smooth, is irregular reflection.

Irregular reflection helps in spreading light energy over a vast region and also decreases its intensity. Thus, it helps in the general illumination of places and helps us to see things around us.

NOTE : Laws of reflection are always valid no matter whether reflection is regular or irregular.

RECTILINEAR PROPAGATION OF LIGHT

Definition :

In simplest terms, rectilinear propagation of light means that light energy travels in straight lines.

Examples of rectilinear propagation of light in everyday life :

(i) When the sunlight enters through a small hole in a dark room, it appears to travel in straight lines.

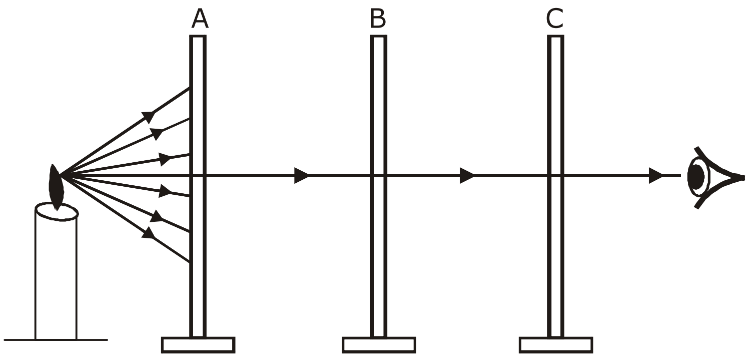
(ii) The light emitted by the head light of a scooter at night appears to travel in straight lines.

(iii) If we almost close our eyes and try to look towards a lighted bulb, it appears to give light in the form of straight lines, which travel in various direction.

Experiment to prove rectilinear propagation of light :

Take three wooden upright A, B and C having a small hole in the middle, such that the holes are at the same height from the base. Arrange the uprights along the edge of a table, such that holes are in the same straight line. Place a lighted candle towards the upright A, such that it is facing the hole. Look through the hole of upright C. The candle flame is clearly visible.

Now displace upright B, slightly towards right or left. It is seen that candle flame is no longer visible. This shows that light travels in straight lines.



MIRROR

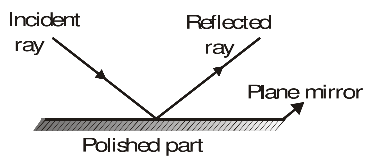
A smooth, highly polished reflecting surface is called a mirror.

When a glass plate is polished on one sided with reflecting material such silver or nickel then is becomes a mirror.

From the reflecting surface of mirror there are two types of mirror.

PLANE MIRROR

A highly polished plane surface is called a plane mirror or if a flat (totally plane) surface of a glass plate is polished one side of reflecting material is called plane mirror.



Formation of image of a point object by a plane mirror :

Consider a plane mirror XY. Let a point object O is placed in front of the mirror as shown in figure.

A ray OA is incident on the plane mirror at right angle to the mirror (i.e. $\angle i = 0$). The reflection takes place at A and the reflected ray retraces its path along AO.

($\therefore \angle r = 0$)

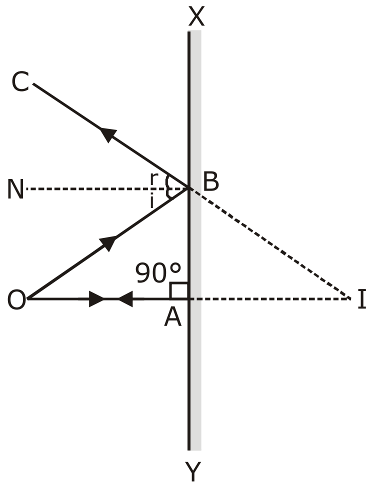


Image of point object

Another ray starting from O incident at point B on the mirror and the reflected ray goes along BC such that $\angle i = \angle r$. The reflected rays AO and BC never meet each other.

When the reflected rays AO and BC are produced backward, they appear to be coming from point I. In other words, reflected rays appear to diverge from point I. So point I is the virtual image of a point object O. Since there is no actual meeting of rays at point I.

The position of image I is as far behind the plane mirror as the position of the object O in front of the plane mirror.

i.e. OA = IA (see in figure).

Formation of image of an extended object by the plane mirror :

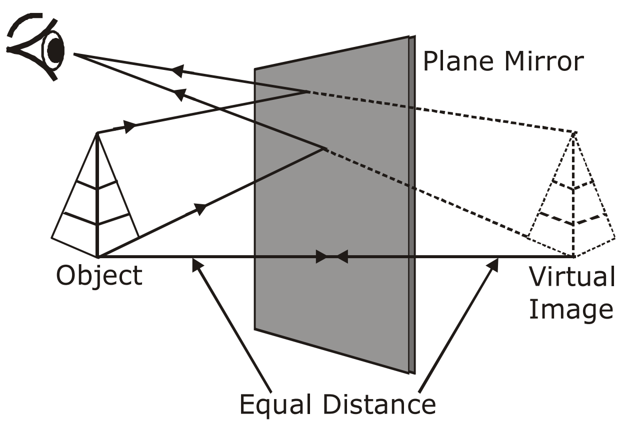


Image of an extended object

Consider an extended object OA (say a pin) placed in front of a plane mirror XY at O. Each point of the object (i.e., pin) acts like a point source of light. The virtual image of each point of the extended object is formed behind the plane mirror as shown in figure. IA' is the virtual image of an extended object OA.

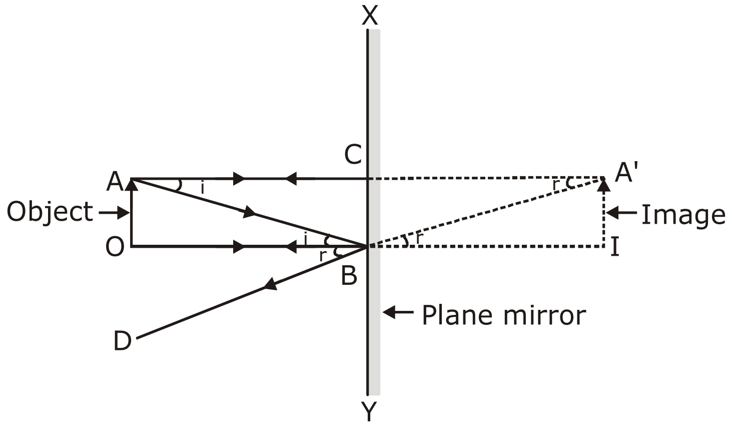


Image of an extended object

In Δ's BAC and BA'C

$\angle i = \angle r$, $\angle ACB = \angle A'CB = 90^o$,

$\therefore$ $\angle ABC = \angle A'BC$

Also BC is common

$\therefore$ ΔABC and $\Delta A'BC$ are congruent by ASA

So AC = A'C i.e. perpendicular distance of object from the mirror is equal to the perpendicular distance of image from the mirror

In Δ's OBA and IBA'

$\angle BOA = \angle BIA' = 90^o$

$\angle OBA = \angle IBA'$ and so $\angle OAB = \angle IA'B$

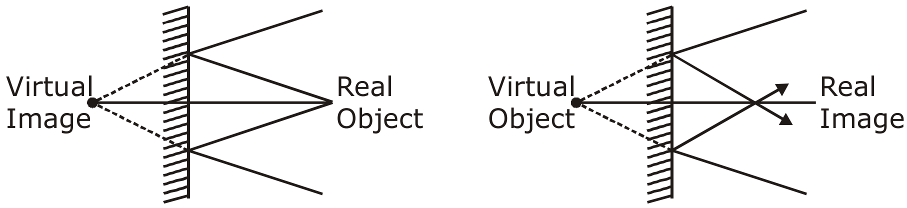
Further as AB = BA' so they are also congruent by ASA

Thus OA = IA'

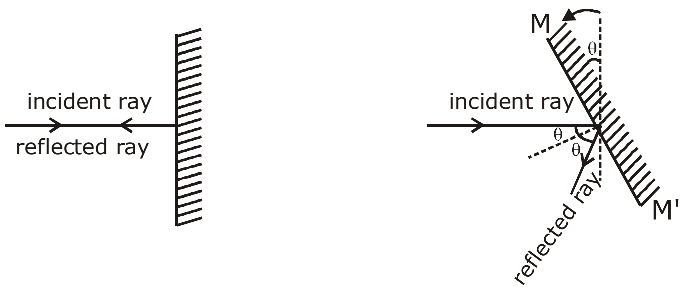
i.e., Size of object = Size of image

Newton's Thought

(i) For a real object the image is virtual and for a virtual object the image is real.



(ii) If keeping the incident ray fixed, the mirror is rotated by an angle θ, about an axis in the plane of mirror, the reflected ray is rotated through an angle 2θ.



LATERAL INVERSION

When we look through the plane mirror, we find that the right eye of the image of our face appears as the left eye and the left eye of the image appears as the right eye. In other words, the right side of the object appears as the left side of the image and vice versa.

This effect is known as lateral inversion.

Definition :

The exchange of the right and left sides of an object and its image is known as lateral inversion.

Demonstration of lateral inversion :

Write a letter P on a card. Place it in front of a plane mirror. We find that letter appears as q, i.e. right of letter. P appears as left side of the image of letter P as shown in figure.

Lateral Inversion

Cause of Lateral inversion :

Lateral inversion is due to the fact that the image of points on the object which are at a lesser distance from the mirror are formed nearer in the mirror and for those the mirror are formed nearer in the mirror and for those points which are at some more distance will be formed at larger distance. So the image appears to be laterally inverted.

Characteristics of the image formed by a plane mirror :

(i) The image formed by a plane mirror is virtual.

(ii) The image formed by a plane mirror is erect.

(iii) The size of the image formed by a plane mirror is same as that of the size of the object. If object is 10 cm high, then the image of this object will also be 10 cm high.

(iv) The image formed by a plane mirror is at the same distance behind the mirror as the object is in front of it. Suppose, an object is placed at 5 cm in front of a plane mirror then its image will be 5 cm behind the plane mirror.

Newton's Thought

If two plane mirrors are kept inclined to each other at angle θ with their reflecting surface facing each other, multiple reflection takes place and more than one images are formed. Number of image (n) for $\theta \le 180°$ are given by:

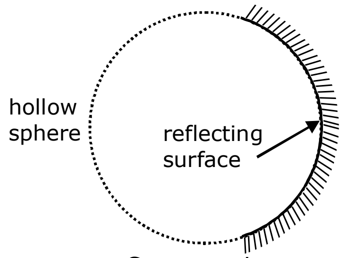
$$n = \begin{cases} \dfrac{360°}{\theta} - 1 \text{ if } \dfrac{360°}{\theta} \text{ is even (object may be placed symmetrically or asymmetrically)} \\ \dfrac{360°}{\theta} - 1 \text{ if } \dfrac{360°}{\theta} \text{ is odd, the object is kept symmetrically (on bisector) w.r.t. the mirrors.} \\ \dfrac{360°}{\theta} \text{ if } \dfrac{360°}{\theta} \text{ is odd, the object is kept asymmetrically (not on bisector) w.r.t. the mirrors.} \\ \dfrac{360°}{\theta} - 1 \text{ if } \dfrac{360°}{\theta} \text{ is not an integer.} \end{cases}$$

SPHERICAL MIRROR

A mirror whose polished, reflecting surface is a part of hollow sphere of glass is called a spherical mirror. For a spherical mirror, one of the two curved surfaces is coated with a thin layer of silver followed by a coating of red lead oxide paint. Thus one side of the spherical mirror is made opaque and the other side acts as a reflecting surface.

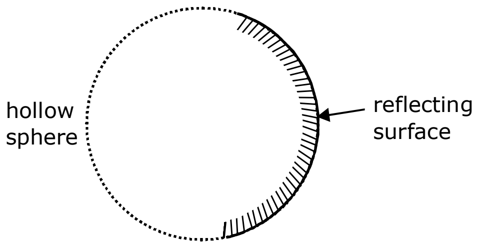
For the polishing side there are two type of spherical mirror.

(A) **Concave (Converging) mirror :** A spherical mirror whose inner hollow surface is the reflecting surface.



Concave mirror

(B) **Convex (diverging) mirror :** A spherical mirror whose outer bulging out surface is the reflecting surface.

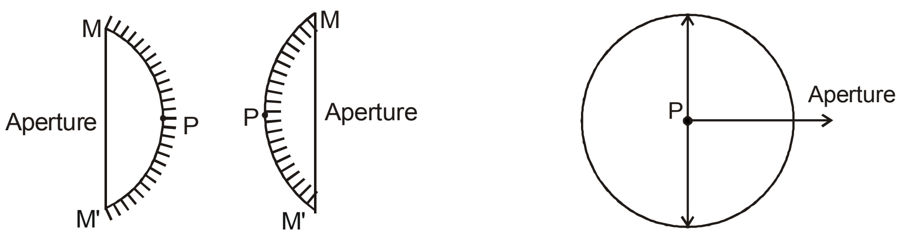


Convex mirror

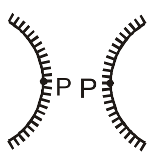
TERMINOLOGY FOR SPHERICAL MIRRORS

(a) **Aperture :** The effective width of a spherical mirror from which reflection can take place is called its aperture AA' & BB'.

The line joining the end points of a spherical mirror is called the aperture or linear aperture.

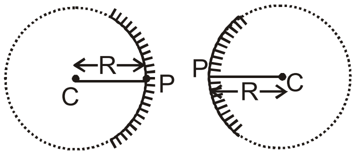


(b) **Pole (Vertex) :** The centre of a spherical mirror is called its pole it is denoted by letter P.

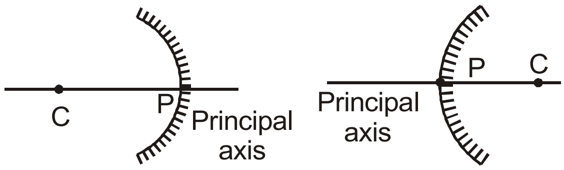


(c) **Centre of curvature :** The centre of the hollow sphere of which the spherical mirror is a part is called centre of curvature. It is denoted by letter C.

(d) **Radius of curvature :** The radius of the hollow sphere of which the spherical mirror is a part called the radius of curvature (R).

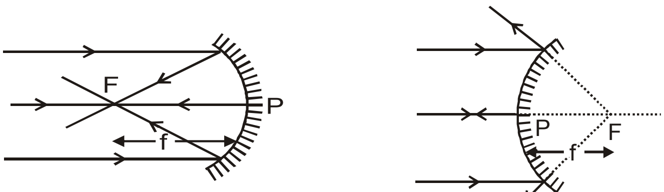


(e) **Principal axis :** The straight line passing through the centre of curvature C and the pole P of the spherical mirror.



(f) **Normal :** The normal at any point of the spherical mirror is the straight line obtained by joining that point with the centre of curvature C of the mirror.

(g) **Principal focus or focus :** The point on the principal axis where all the rays coming from infinity (parallel rays) after reflection either actually meets or appears to meet is called the focus (or focal point) of the mirror. It is denoted by letter F.



Concave mirror

Convex mirror

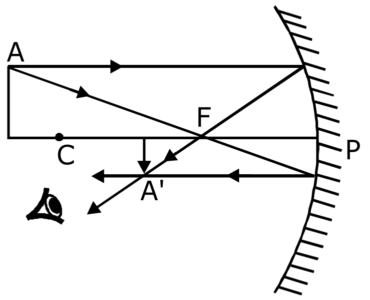
(h) **Focal length :–** The distance between the pole (P) and the focus (F) is called focal length (f) and

$$f = \frac{R}{2}$$

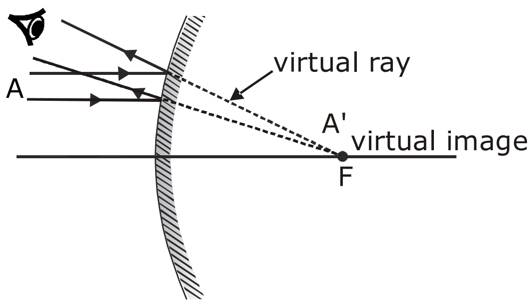
(i) **Focal plane :-** An imaginary plane passing through the focus and at right angles to the principal axis.

(j) **Paraxial Rays :** The ray which have very small angle of incidence are known as paraxial rays.

(k) **Real Image :-** When the rays of light after getting reflected from a mirror (or after getting refracted from a lens) – actually meet at a point, a real image is formed. A real image can be obtained on a screen.



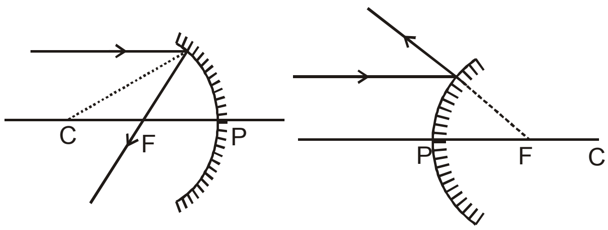
(l) **Virtual Image :** When the rays of light after getting reflected from a mirror (or after getting refracted from a lens) appear to meet at a point, a virtual image is formed. Such an image can only be seen through a mirror (or a lens) but cannot be obtained on a screen.



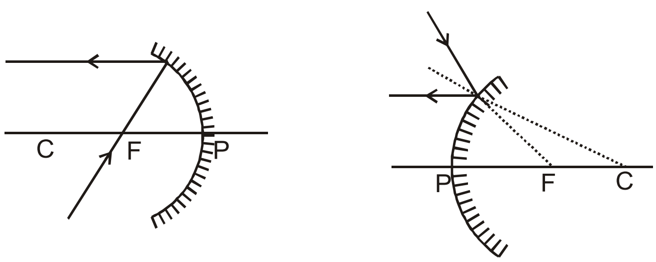
RULES FOR IMAGE FORMATION

The reflection of light rays and formation of images are shown with the help of ray diagrams. Some typical incident rays and the corresponding reflected rays are shown below.

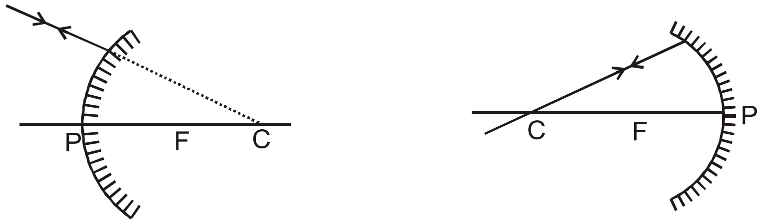
(i) A ray passing parallel to the principal axis, after reflection from the spherical mirror passes or appears to pass through its focus (by the definition of focus)



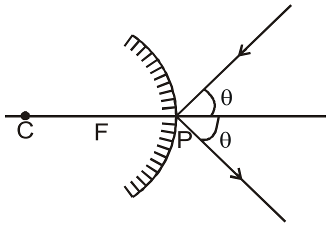
(ii) A ray passing through or directed towards focus, after reflection from the spherical mirror becomes parallel to the principal axis (by the principal of reversibility of light).



(iii) A ray passing through or directed towards the centre of curvature, after reflection from the spherical mirror, retraces its path (as for it $\angle i = 0$ and so $\angle r = 0$)



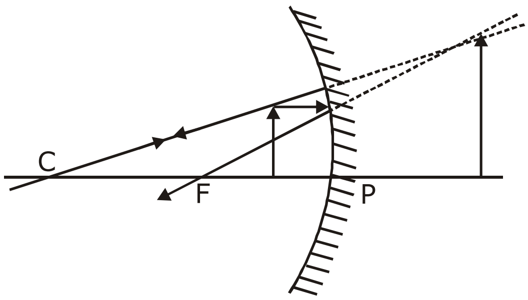
(iv) It is easy to make the ray tracing of a ray incident at the pole as shown in below.



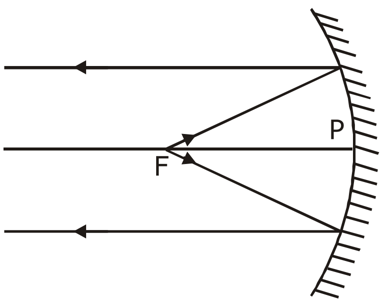
FORMATION OF IMAGE FROM A CONCAVE MIRROR

Formation of images by concave mirror

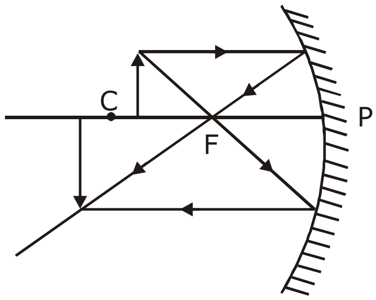
(i) When the object is placed between the pole and the focus, then the image formed is virtual, erect and magnified.



(ii) When the object is placed at the focus then the image is formed at infinity. The image is extremely magnified.

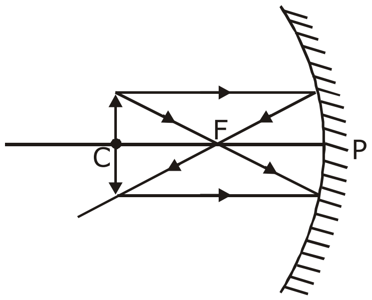


(iii) When the object is placed between the focus and the centre of curvature then the image is formed beyond the centre of curvature. The image formed is real, inverted and bigger than the object.

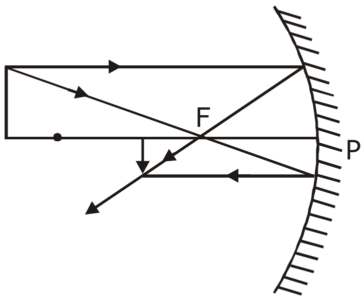


(iv) When the object is placed at the centre of curvature, then the image is formed is formed at the centre of curvature.

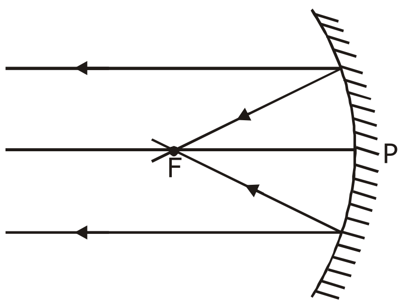
The image formed is real, inverted and equal to the size of the object.

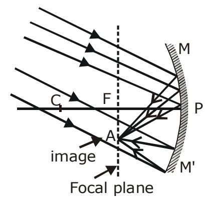
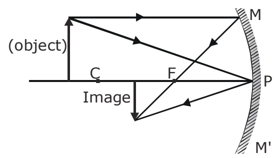
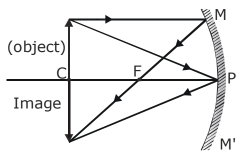
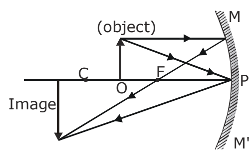
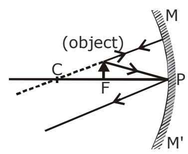
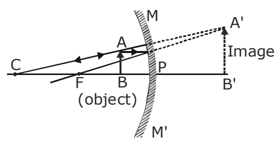


(v) When the object is placed beyond the centre of curvature, then the image is formed between the focus and centre of curvature. The image formed is real, inverted and diminished.



(vi) When the object is placed at infinity then the image is formed at the focus. The image formed is real, inverted and extremely diminished in size.



S. No.	Position of the object	Position of the image	Nature & size of the image	Ray diagram
(1)	At infinity.	At focus F	Real, inverted and highly diminished. (point size)	
(2)	Between infinity and C	Between C & F	Real, inverted and smaller than the object	
(3)	At C	At C	Real, inverted and same size.	
(4)	Between C & F	Between C and infinity.	Real, inverted and enlarged.	
(5)	At F	At infinity.	Real, inverted and infinitely large.	
(6)	Between focus and pole	Behind the mirror.	Virtual, erect and enlarged.	

Use of Concave mirror

(i) It is used as a shaving mirror.

(ii) It is used as a reflector in the head light of vehicles.

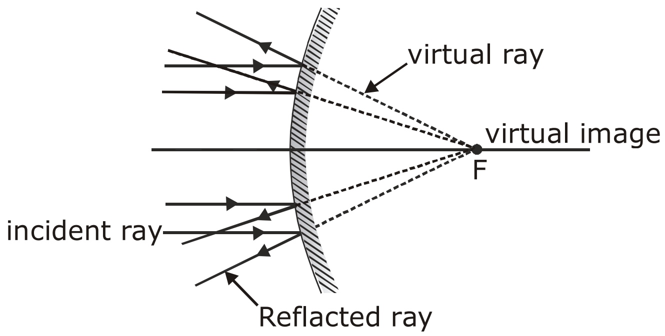
(iii) It is used by doctor to focus a parallel beam of light on a small area.

FORMATION OF IMAGE FROM A CONVEX MIRROR

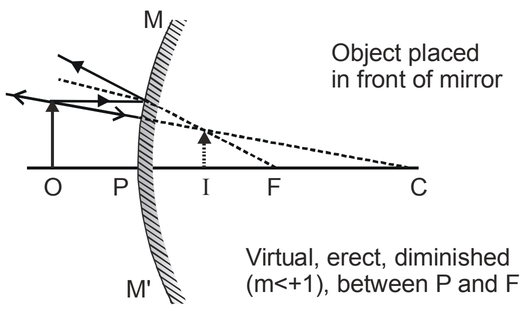
(i) When the object is at infinity

When the rays of light coming (diverging) from an object, situated at infinity are always parallel these parallel rays, strike the convex mirror, and reflected to diverge outward from convex mirror. These rays seems (appear) to come from focus.

The characteristics of the image is virtual, erect, diminished to a point and formed at principal focus behind the convex mirror.



(ii) When the object is at a finite distance from the pole then the image is formed between pole and principal focus behind the convex mirror and image is virtual, erect and diminished.



Note :

There are only two position of the object for showing the image formed by a convex mirror that is –

(i) When the object is at a infinity.

(ii) When the object is at a finite distance from the pole of the convex mirror. Beside this positions are not possible because the focus and the centre of curvature is behind the reflecting surface of the convex mirror.

Now we can study the image formation by following table

S.No.	Position of the object	Position of the image	Size of image of the image	Nature of the image
(1)	At infinity	At F, behind mirror	Highly diminished	Virtual and erect.
(2)	Between infinity and pole of mirror.	Between P & F behind the mirror	Diminished	Virtual and erect.

Uses of Convex mirror

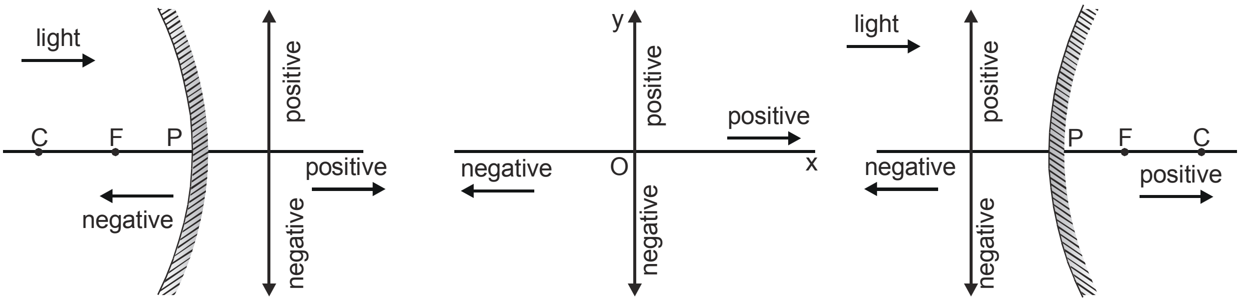
(i) It is used as a rear view mirror in automobile.

(ii) It is used as a reflector for street light.

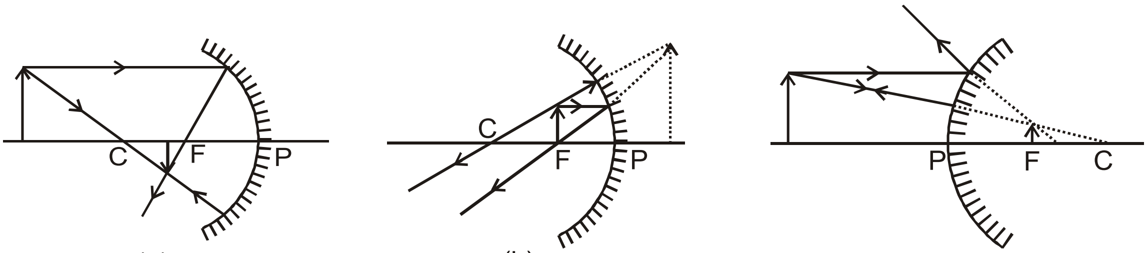
Note : A plane mirror is not useful as a rear view mirror, because its field of view is very small.

SIGN CONVENTION OF SPHERICAL MIRROR

- Whenever and wherever possible the ray of light is taken to travel from left to right.
- The distances above principal axis are taken to be positive while below it negative.
- Along principal axis, distances are measured from the pole and in the direction of light are taken to be positive while opposite to it is negative.



Ex.1



(a) (b) (c)

Figure	u	v	R	f
(a)	–Ve	–Ve	–Ve	–Ve
(b)	–Ve	+Ve	–Ve	–Ve
(c)	–Ve	+Ve	+Ve	+Ve

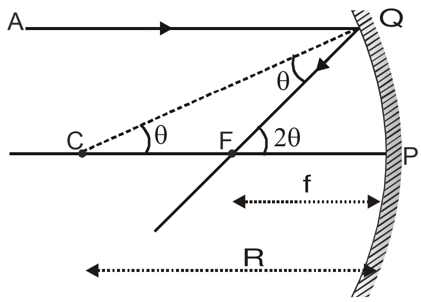
Important Points Regarding Sign Convention :

In this sign convention, focal length of a concave mirror is always negative while the focal length of a convex mirror is always positive.

Assume the pole to be (0, 0).

RELATION FROM SPHERICAL MIRROR

Relation between f and R for the spherical mirror



If Q is near to line P then from ΔQCP $\tan\theta \simeq \theta = \dfrac{QP}{R}$

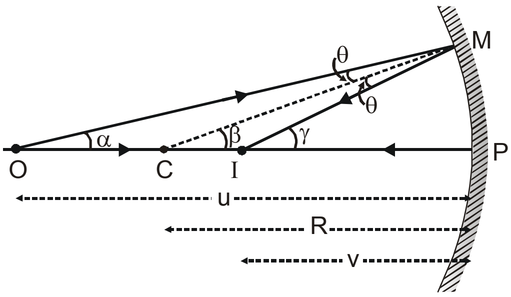
and from ΔQFP $\tan 2\theta \simeq 2\theta = \dfrac{QP}{f}$

so $\dfrac{2QP}{R} = \dfrac{QP}{f} \Rightarrow f = \boxed{f = \dfrac{R}{2}}$

Relation between u,v and f for curved mirror

If an object is placed at a distance u from the pole of a mirror and its image is formed at a distance v (from the pole)

If angle is very small : $\alpha = \frac{MP}{u}$, $\beta = \frac{MP}{R}$, $\gamma = \frac{MP}{v}$



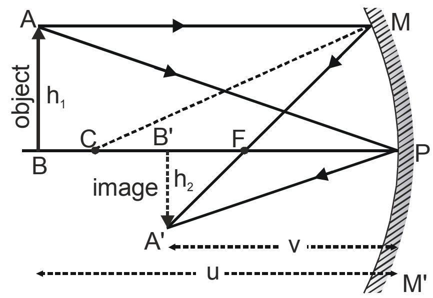
from ΔCMO, $\beta = \alpha + \theta \Rightarrow \theta = \beta - \alpha$

from ΔCMI, $\gamma = \beta + \theta \Rightarrow \theta = \gamma - \beta$

so we can write $\beta - \alpha = \gamma - \beta \Rightarrow 2\beta = \gamma + \alpha$

$$\therefore \frac{2}{R} = \frac{1}{v} + \frac{1}{u} \Rightarrow \boxed{\frac{1}{f} = \frac{1}{u} + \frac{1}{v}}$$

MAGNIFICATION



Linear magnification $m = \frac{\text{size of image}}{\text{size of object}} = \frac{I}{O}$

ΔABP and $\Delta A'B'P$ are similar $\frac{-h_2}{h_1} = \frac{-v}{-u} \Rightarrow \frac{h_2}{h_1} = -\frac{v}{u}$

Magnification $\boxed{m = -\frac{v}{u}}$ $\Rightarrow$ $m = -\frac{v}{u} = \frac{f}{f-u} = \frac{f-v}{f} = \frac{h_2}{h_1}$

POWER OF A MIRROR

The power of a mirror is defined as $\boxed{P = -\frac{1}{f(m)} = -\frac{100}{f(cm)}}$

In convex mirror the field of view is increased as compared to plane mirror.

It is used as rear-view mirror in vehicles.

Concave mirrors give enlarged, erect and virtual image, so these are used by dentists for examining teeth. due to their converging property concave mirrors are also used as reflectors in automobile head lights and search lights

A real image can be taken on a screen, but a virtual image cannot be taken on a screen.

As focal length of a spherical mirror $f = \frac{R}{2}$ depends only on the radius of mirror and is independent of wavelength of light and refractive index of medium so the focal length of a spherical mirror in air or water and for red or blue light is same.

MIRROR FORMULA

The relation between the distance of the object from the pole of the spherical mirror (u), the distance of the image from the pole of the spherical mirror (v) and its focal length (f) is given by the mathematical formula :

$$\boxed{\frac{1}{f}=\frac{1}{u}+\frac{1}{v}}$$

It must be remembered that focal length (f) of a spherical mirror is half the radius of curvature (R).

Thus, (i) $R = 2f$, (ii) $f = \frac{R}{2}$

Important points in using the mirror formula :

(i) Put the correct signs of known variables according to the sign convention.

(ii) Do not put the sign of an unknown variable. The sign will be automatically come up during calculations.

(iii) If the calculated sign turns out to be positive, then the variable calculated is behind the mirror. However, if calculated sign turns out to be negative, then variable is to be in front of the mirror.

Linear magnification produced by spherical morrors :

The ratio between the height of the image produced by the spherical morror to the height of the object is called the linear magnification.

Thus, linear magnification = $\frac{\text{Height of the image}}{\text{Height of the object}}$ or $\boxed{m=\frac{h_i}{h_o}}$

Linear magnification when the image is real:

As we normally take the object above the principal axis, therefore, h_0 is always positive. The real image is always inverted and is formed below the principal axis.

Therefore, h_i is always negative. Thus, Linear magnification for real images $= -\frac{h_i}{h_o}$ is always negative.

Linear magnification when the image is virtual :

In case of virtual image. it is erect and formed above the principal axis. Thus, h_0 and h_i are both positive.

The linear magnification produced by a spherical mirror is equal to the ratio of the distance of the image from the pole of the mirror (v) to the distance of the object from the pole of the mirror (u) with a minus sign.

Linear magnification, $m = -\frac{v}{u}$, Thus Linear magnification, $m = \frac{h_i}{h_o} = -\frac{v}{u}$.

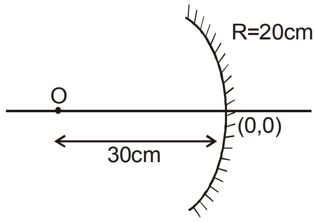
Important points in using magnification formula :

(i) Put the correct signs of known variables according to the sign convention.

(ii) If 'm' is known, take the sign for virtual image positive and for real image negative.

(iii) Do not put the sign of unknown variables. The sign will automatically come up during calculations.

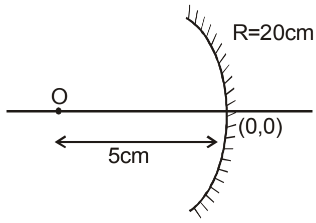
Ex.2 Find out the position and type of image formed.



Sol. $\frac{1}{f}=\frac{1}{u}+\frac{1}{v} \qquad \Rightarrow \frac{-1}{10}=\frac{-1}{30}+\frac{1}{v} \Rightarrow \frac{1}{v}=\frac{1}{30}+\frac{-1}{10}=\frac{1-3}{30}=\frac{-2}{30}=\frac{-1}{15}\text{cm}$

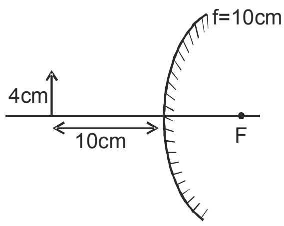
V = – 15cm (Real image)

Ex.3 Find out the position and type of image formed.



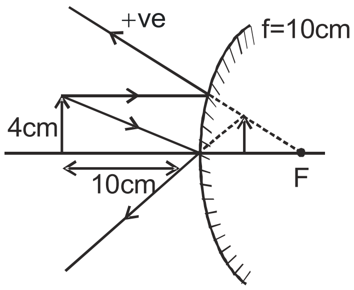
Sol. $\frac{1}{f}=\frac{1}{u}+\frac{1}{v} \quad \Rightarrow \frac{-1}{10}=\frac{-1}{5}+\frac{1}{v} \quad \Rightarrow \frac{1}{v}=\frac{1}{5}-\frac{1}{10}=\frac{2-1}{10}=\frac{1}{10}$

$\therefore$ V = + 10 (Virtual image)



Ex.4 Findout the position, height and type of image.

Sol. $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$



$\Rightarrow \frac{+1}{10}=\frac{1}{v}-\frac{1}{10} \qquad \Rightarrow \frac{1}{v}=\frac{+1}{10}+\frac{1}{10} \Rightarrow$ V = + 5cm

$\frac{h_i}{4}=\frac{-5}{-10} \Rightarrow h=+2\text{cm}$

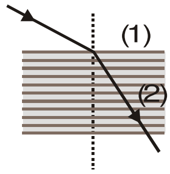
REFRACTION OF LIGHT

Deviation or bending of light rays from their original path while passing from one medium to another is called refraction. It is due to change in speed of light as light passes from one medium to another medium. If the light is incident normally then it goes to the second medium without bending, but still it is called refraction.

Refractive index of a medium is defined as the factor by which speed of light reduces as compared to the speed of light in vacuum.

The refractive index, of medium 2 with respect to medium 1, equals the ratio of the speed of light in medium 1 to its speed in medium 2. Thus,

$$\begin{array}{c}\text{Refractive index}\\ \text{(or medium 2 w.r.t. medium 1)}\end{array} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}}$$



Medium 1 is usually air. When we say that the refractive index of water is 1.33 (or 4/3), it means that the speed of light, in water, is 3/4th of its value in air.

$$\mu = \frac{c}{v} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

More (less) refractive index implies less (more) speed of light in that medium, which therefore is called denser (rarer) medium.

NOTE:-

- Higher the value of Refractive index denser (optically) is the medium.
- Frequency of light does not change during refraction

LAWS OF REFRACTION

(a) The incident ray, the normal to any refracting surface at the point of incidence and the refracted ray all lie in the same plane called the plane of incidence or plane of refraction.

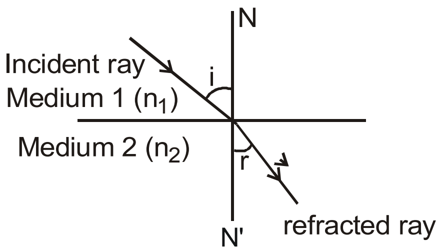
(b) $\boxed{\dfrac{\sin i}{\sin r} = \text{Constant}}$ for any pair of media and for light of a given wavelength.

This is known as ***Snell's*** *Law.*

Also, $\dfrac{\sin i}{\sin r} = \dfrac{n_2}{n_1} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2}$

For applying in problems remember

$$\mathbf{n_1 \sin i = n_2 \sin r}$$



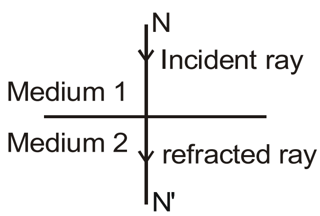
$\dfrac{n_2}{n_1} = {}_1n_2$ = Refractive Index of the second medium with respect to the first medium.

C = speed of light in air (or vacuum) = 3×10^8 m/s.

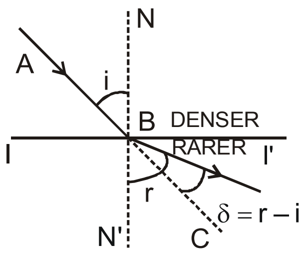
i & r should be taken from normal.

Special cases :

- Normal incidence : i = 0
  from Snell's law : r = 0

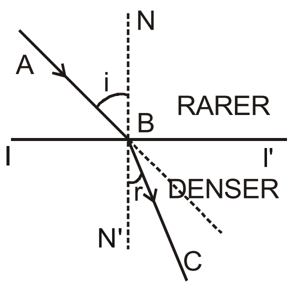


- When light moves from denser to rarer medium it bends away from normal.



r>i

- When light moves from rarer to denser medium it bends towards the normal.

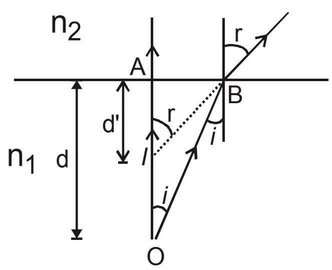


APPARENT DEPTH AND NORMAL SHIFT

When the object is in denser medium and the observer is in rarer medium (near normal incidence)

When an object O is in denser medium of depth 'd' and absolute refractive index n_1 and is viewed almost normally to the surface from the outside rarer medium (r.i = n_2), its image is seen at I. which is at a distance d′ from surface AO is the real depth of the object. AI is the apparent depth of the object. O*I* is called apparent shift.

According to Snell's law, $\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$



or, $\frac{n_2}{n_1} = \frac{\tan i}{\tan r}$ ($\because$ i and r are small angles)

$$\frac{n_2}{n_1} = \frac{AB}{AO} \times \frac{AI}{AB}$$

$$\mathbf{\frac{n_2}{n_1} = \frac{d'}{d} = \frac{apparent\ depth}{Real\ depth}}$$

NOTE:-

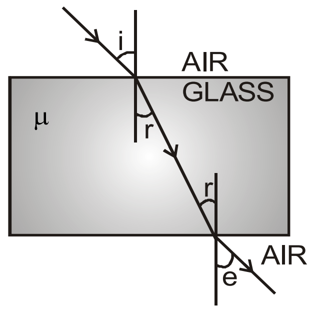
1. The above formula is value only for paraxial rays.
2. distances should be taken from surface
3. n_2 is the reflective index of the medium, where ray is going and n_1 from where ray is coming

REFRACTION THROUGH A GLASS SLAB

When a light ray passes through a glass slab having parallel faces, it gets refracted twice before finally emerging out of it.

First refraction takes place from air to glass.

So, $\mu = \dfrac{\sin i}{\sin r}$ ...(i)



The second refraction takes place from glass to air.

So, $\dfrac{1}{\mu} = \dfrac{\sin r}{\sin e}$ ...(ii)

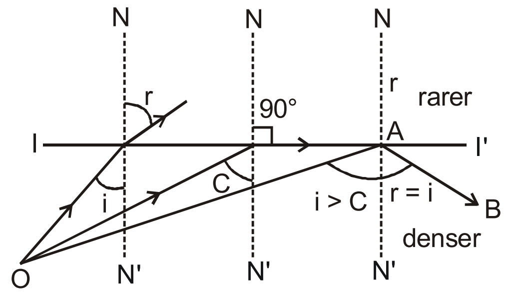
From equations (i) and (ii), we get

$$\frac{\sin i}{\sin r} = \frac{\sin e}{\sin r} \Rightarrow \mathbf{i = e}$$

Thus, the emergent ray is parallel to the incident ray.

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION (T.I.R.)

Critical angle is the angle made in denser medium for which the angle of refraction in rarer medium is 90°. When angle in denser medium is more then critical angle the light ray reflects back in denser medium following the laws of reflection and the interface behaves like a perfectly reflecting mirror. In the figure.



O = object

NN′ = Normal to the interface

II′ = Interface

C = Critical angle :

AB = reflected ray due to T.I.R.

When i = C then r = 90°

$\therefore \boxed{C = \sin^{-1}\dfrac{n_r}{n_d}}$

Ex.5 Find the max. angle that can be made in glass medium (μ = 1.5) if a light ray is refracted from glass to vacuum.

Sol. 1.5 sin C = 1 sin 90°, where C = critical angle.

sin C = 2/3 $\Rightarrow$ C = $\sin^{-1}2/3$

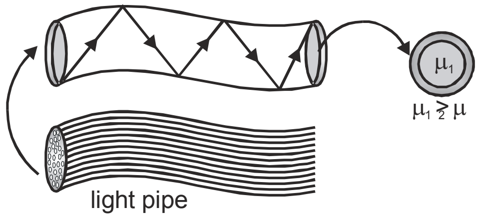
SOME ILLUSTRATIONS OF TOTAL INTERNAL REFLECTION

◎ **Sparkling of diamond**

The sparkling of diamond is due to total internal reflection inside it. As refractive index for diamond is 2.5 so $\theta_C = 24°$. Now the cutting of diamond are such that $i > \theta_C$. So TIR will take place again and again inside it. The light which beams out from a few places in some specific directions makes it sparkle.

◎ **Optical Fibre**

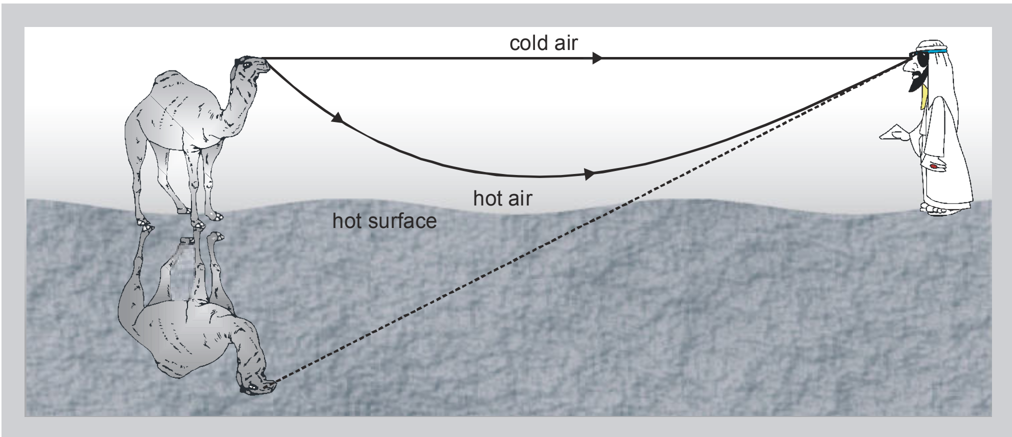
In it light through multiple total internal reflections



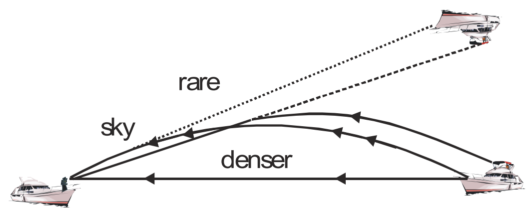
is propagated along the axis of a glass fibre of radius of fewmicrons in which index of refraction of core is greater than that of surroundings.

◎ **Mirage and looming**

Mirage is caused by total internal reflection in deserts where due to heating of the earth, refractive index of air near the surface of earth becomes lesser than above it. Light from distant objects reaches the surface of earth with $i > \theta_C$ so that TIR will take place and we see the image of an object along with the object as shown in figure.



Similar to 'mirage' in deserts, in polar regions 'looming'



takes place due to TIR. Here μ decreases with height and so the image of an object is formed in air if $(i > \theta_C)$ as shown in Fig.

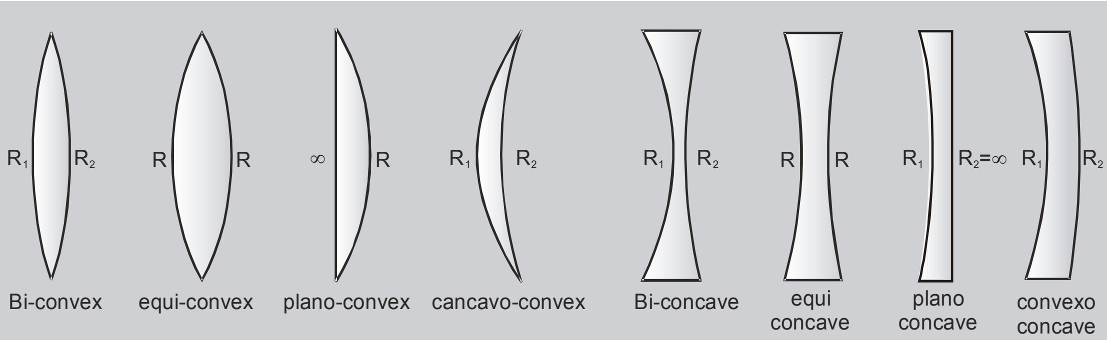
GOLDEN KEY POINTS

- A diver in water at a depth d sees the world outside through a horizontal circle of radius. $r = d \tan \theta_C$.
- For total internal reflection to take place light must be propagating from denser to rarer medium.
- In case of total internal reflection, as all (i.e. 100%) incident light is reflected back into the same medium there is no loss of intensity while in case of reflection from mirror or refraction from lenses there is some of intensity as all light can never be reflected or refracted. This is why images formed by TIR are much brighter than formed by mirrors or lenses.

REFRACTION THROUGH THIN LENSES

Lens : A lens is a transparent medium bounded by two refracting surfaces such that at least one of the refracting surfaces is curved. (or spherical)

Types of lenses. : Broadly, lenses are of the following types :

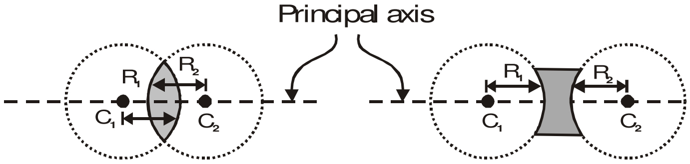


SOME DEFINITIONS

Let us first understand the meanings of a few terms relevant to the lenses.

Centres of curvature : Each of the two surfaces of a spherical lens can be regarded as a part of a sphere. The centres of these two spheres are known as the centres of curvature or the two surfaces of the lens.

Radii of curvature : The radii of the two spheres, of which the lens surfaces are a part of, are known as the radii of curvature or the two surfaces of the lens.

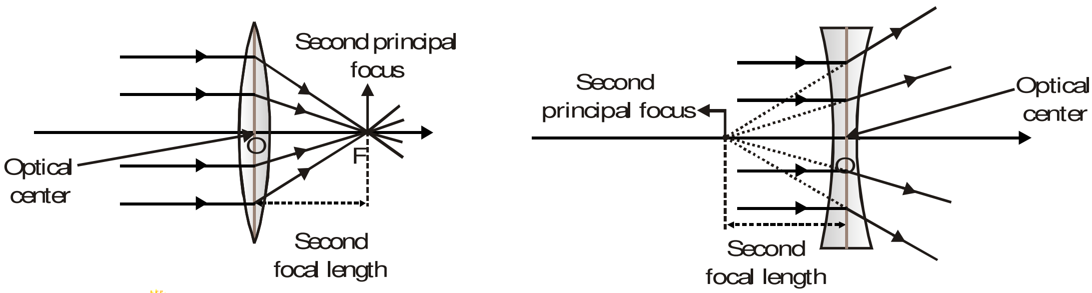


Principal axis : The line joining the centres of curvature of the two surfaces of a lens is known as its principal axis.

Optical centre : The **optical centre** of a lens is a special point on its principal axis. A ray of light passing through the optical centre of a lens, goes straight through it without undergoing any bending or deviation from its path.

Principal Focus/Focal length : It turns out that if a beam of rays, all parallel to the principal axis of a lens, falls on the lens, they either all converge to a point on its principal axis, or appear to diverge from a point on its principal axis. We call this point as the (second) principal focus of the lens.

The distance of the (second) principal focus from the optical centre of a lens, equals the focal length of the lens.

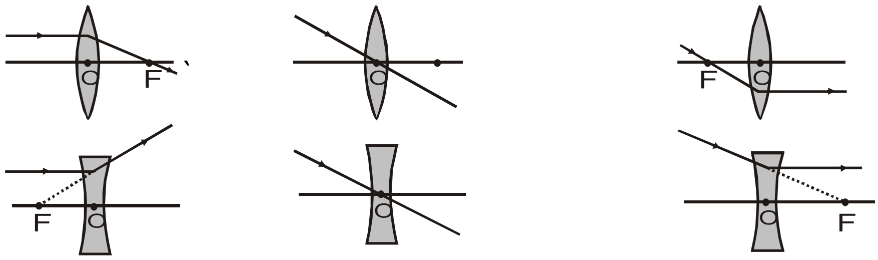


Three Special Rays for Lenses : We can use the ideas and definitions, outlined above, to draw **ray diagrams** for lenses. These ray diagrams help us to know the nature, size and position of the image formed when the object is kept at different distances from the lens. We prefer to use two of the three (special) incident rays given below, to draw these ray diagrams.

(i) An incident ray, parallel to the principal axis, passes through (or appears to come from, the (second) principal focus of the lens.

(ii) An incident ray, passing through the optical centre of the lens, goes undeviated from the lens.

(iii) An incident ray, passing through the (first) principal focus of the lens, or directed towards it, becomes parallel to the principal axis after refraction from the lens.



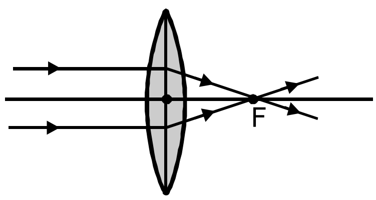
(i) (ii) (iii)

Let us now see how we can use any two of these three (special) incident rays to draw ray diagrams, for different object positions, for a convex lens and a concave lens.

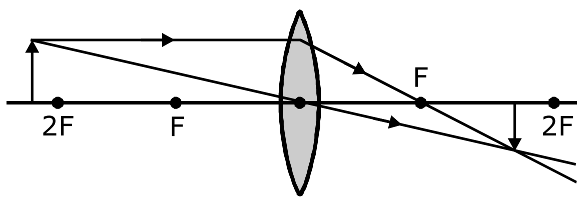
CONVEX LENS

A convex lens forms images of different sizes, nature, and at different positions, for objects kept at different distances from its optical centre. We consider the following five cases that cover all possible types of image formed by this lens. The ray diagrams have been drawn using (up to) two of the three (special) rays mentioned above. The characteristics, of the image formed, have been written along with the corresponding ray diagram.

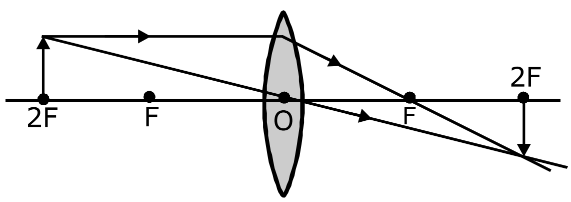
(i) **Object at infinity :** The image of a very far off object (object at infinity) is a real, diminished and almost point like image. It is formed at the focus of the lens.



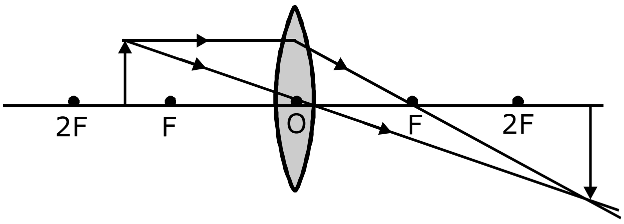
(ii) **Object beyond the '2F' point of the lens :** The image formed here is a real, diminished, inverted image. It is formed between the 'F' and '2F' point of the lens, on its other side (the side opposite to the side on which the object has been put).



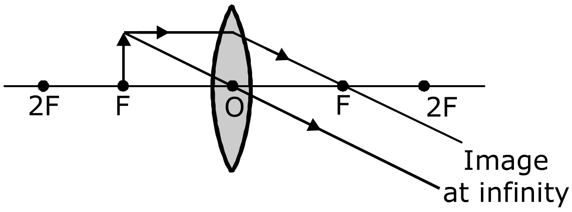
(iii) **Object at the '2F' point of the lens :** The image formed here is a real, inverted image that has the same size as the object. It is formed at the '2F' point, of the lens, on the other side of the lens.



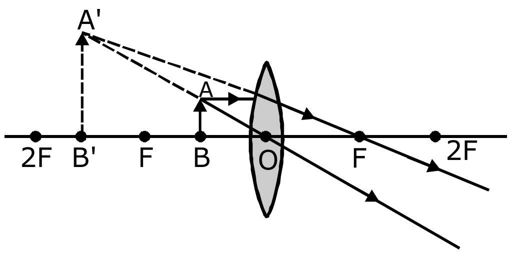
(iv) Object between the '2F' and 'F' point of the lens : The image formed here is a real, inverted and magnified image. It is formed beyond the **'2F'** point of the lens on its other side.



(v) Object kept at the (first) principal focus or the 'F' point of the lens : The image formed here is taken as a real, inverted and magnified image. It is regarded as formed very far off or at infinity.

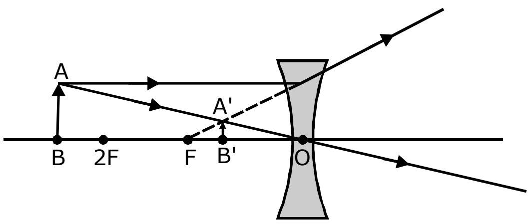


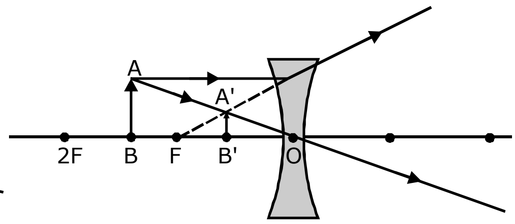
(vi) Object between the optical centre and the 'F' point of the lens : The image formed here is a virtual erect and magnified image. It appears to be formed beyond the 'F' point of the lens on the same side as the object is.

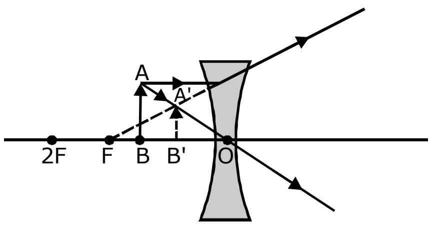


CONCAVE LENS

Unlike a convex lens, the nature and position of the image, formed by a concave lens, does not depend upon the distance of the object from the lens. A **concave lens always** forms of **virtual, erect** and **diminished image.** Also, the image always appears to be located between the optical centre and the 'F' point of the lens on the same side as the object is. We illustrate these features of the concave lens by drawing 'ray diagrams' for three different distances of the object from the lens.







In all cases, the image formed is a **virtual, erect** and **diminished** one. Also, it always appears to be formed between the optical centre and the 'F' point of the lens.

POWER OF A LENS

It is the measure of deviation produce by a lens. It is defined as the reciprocal of its focal length in metres. Its unit is Diopter (D) (f should always be in metres.)

Power (P) = $\boxed{\textbf{Power(P)} = \dfrac{\textbf{1}}{\textbf{focal length (f in m)}}}$

Power of a convex lens is +ve (As it has a real focus and its focal length measured is +ve.)
Power of a concave lens is –ve (As it has a virtual focus and its focal length measured is –ve.)

NOTE
If two thin lenses are placed in contact, the combination has a power equal to the algebraic sum of the powers of two lenses, $\mathbf{P = P_1 + P_2}$

$$\Rightarrow \qquad \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Here, f_1 and f_2 are the focal length of lenses and f is focal length of combination of lenses.

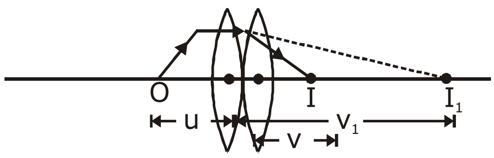
LENS FORMULA

Relation between object distance u, image distance v and focal length f is :

$$\boxed{\frac{1}{v} - \frac{1}{u} = \frac{1}{f}}$$

Newton's Thought

Lenses in Contact
Consider two thin lens of focal lengths, f_1 and f_2 respectively placed in contact with each other.
Let O be the point object placed on the principal axis of the lenses. If second lens is not present, then the first lens forms an image I_1 of the object O at a distance v_1 from it.



Using lens formula $-\dfrac{1}{u} + \dfrac{1}{v_1} = \dfrac{1}{f}$ ......(i)

Since second lens is in contact with the first, So I_1 acts as an object for the second lens which forms the image I at a distance v from it.

or $\quad -\dfrac{1}{v_1} + \dfrac{1}{v} = \dfrac{1}{f_2}$ ......(ii)

Adding equation (i) and (ii), we get

$$-\frac{1}{u} + \frac{1}{v} = \frac{1}{f_1} + \frac{1}{f_2} \text{ or } -\frac{1}{u} + \frac{1}{v} = \frac{1}{F}$$

where, $\dfrac{1}{F} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$

F is equivalent focal length.
The power of the equivalent lens is given by $P = P_1 + P_2$
Magnification, $m = m_1 \times m_2$

LINEAR MAGNIFICATION

Linear magnification (m) is defined as the ratio of the size of the image to the size of the object.

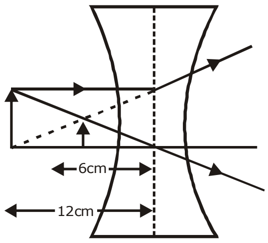
$$m = \frac{A'B'}{AB} = \frac{h_2}{h_1} = \frac{\text{height of image}}{\text{height of object}}$$

$$\text{also } m = \frac{v}{u} \quad \begin{Bmatrix} \text{if m is + ve (image is virtual \& erect} \\ \text{if m is – ve (image is real \& inverted} \end{Bmatrix}$$

ILLUSTRATIONS

1. An object is placed 12 cm away from the optical centre of a lens. Its image is formed exactly midway between the optical centre and the object :
(i) Draw a ray diagram to show the image formed.
(ii) Calculate the focal length of the lens used.

Sol. (i) The ray diagram is shown below.
The image is virtual, erect and a diminished image.
(ii) Using lens formula



$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we have

$$\frac{1}{(-6)} + \frac{1}{(-12)} = \frac{1}{f}$$

$$\frac{1}{f} = -\frac{1}{6} + \frac{1}{12} = \frac{-2+1}{12} = -\frac{1}{12}$$

2. Two thin convex lenses of focal lengths 10cm and 20cm are placed in contact. Find the effective power of the combination.

Sol. $P = P_1 + P_2$

$$P = \frac{100}{f_1} + \frac{100}{f_2}$$

$$= \frac{100}{10} + \frac{100}{20} = 10 + 5 = 15D$$

3. An illuminated object and a screen are placed 90cm. apart. What is the focal length and nature of the lens required to produce a clear image on the screen, twice the size of the object?

Sol. As the image is real, the lens must be a convex lens and it should be placed between the object and the screen.
Let distance between the object & the convex lens be x
then $u = -x, v = 90 - x$

Now $m = \frac{v}{u} = -2$(image is real)

$$\frac{90 - x}{-x} = -2 \Rightarrow x = 30$$

$\therefore$ u = −30 cm, v = +60 cm.
Now,

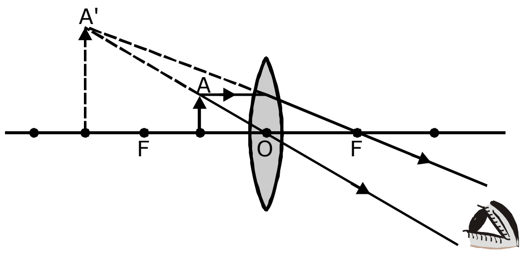
$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{60} - \frac{1}{-30} = \frac{1}{60} + \frac{1}{30} = \frac{3}{60} = \frac{1}{20}$$

$\therefore$ f = 20 cm.

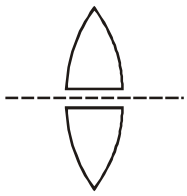
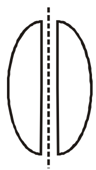
APPLICATION OF LENSES

Lenses find a number of uses in our day- to-day life. The simplest of such applications include the **magnifying glass,** the **microscope**, the **telescope** and the **photographic camera**. And, of course, that wonderful gift of nature to mankind the eye also has a 'built-in' lens that plays a very important role in its functioning.

The Magnifying Glass (The simple Microscope) : The magnifying glass, or a **simple microscope,** is simply a convex lens of short focal length. We have seen above that the convex lens produces a virtual, erect and magnified image of an object when the object is kept within the focal point of the lens. it turns out that the smaller the focal length of a lens, the more is the magnification produced by it. We often use a (small focal length) convex lens, provided with a frame and a handle, as a simple **magnifying glass** or as a **reading lens.** However, we can use such a lens for producing a magnification of 5 to 10 times only.



The Simple Microscope

Newton's Thought
IMPORTANT NOTE
(1) Intensity or brightness of the image is proportional to the square of the aperture of the lens i.e. Intensity of image $\propto$ $(\text{Aperture})^2$
(2) If a lens is cut horizontally into two equal halves as shown in figure, then focal length remains unchanged. 
(3) If a lens is cut vertically into two equal halves as shown in figure, then focal length becomes double. 

NCERT QUESTIONS WITH SOLUTIONS

Q.1 Define the principal focus of a concave mirror.

Ans. A point on the principal axis where the parallel rays of light after reflecting from a concave mirror meet.

Q.2 The radius of curvature of a spherical mirror is 20cm. What is focal length?

Ans. Radius of curvature, R = 20cm

$\therefore$ Focal length, $f = \frac{R}{2} = \frac{20}{2} = 10$ cm

Q.3 Name a mirror that can give an erect and magnified image of an object.

Ans. A concave mirror.

Q.4 Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Ans. This because a convex mirror forms an erect and diminished (small in size) images of the objects behind the vehicle and hence the field of view behind the vehicle is increased.

Q.5 Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Ans. R = +32 cm. Therefore, f = R/2 = +3/2 = +16cm

Thus, focal length of the convex mirror = +16cm

Q.6 A concave mirror produces three times magnified (enlarged) real image of an object placed at 10cm in front of it. Where is the image located?

Ans. $m = -3,$

But $m = \upsilon/u,$ so, $v = 3u$

$u = -10\text{cm}, v = 3(-10 \text{ cm}) = -30\text{cm}$

Thus, the image is located at a distance of 30cm to the left side of the concave mirror.

Q.7 A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

Ans. The ray of light bends towards the normal because the speed of light decreases when it goes from air (rarer medium) into water (denser medium).

Q.8 Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum in 3×10^8 ms^{-1}.

Ans. $n = \frac{c}{\upsilon}$ $\therefore \upsilon = \frac{3 \times 10^8 ms^{-1}}{1.50} = 2 \times 10^8$ ms^{-1}

Thus, speed of light in glass = $2 \times 10^8 ms^{-1}$

Q.9 You are given kerosene, turpentine and water. In which of these does the light travel faster?

Ans. We know, $\upsilon = \frac{c}{n}$ Refractive index (n) of water is 1.333, whereas refractive index of kerosene is 1.44 and that of turpentine is 1.47. As refractive index of water is least, so speed of light in water is more than in kerosene and turpentine. Hence, light travels faster in water.

Q.10 The refractive index of diamond is 2.72. What is the meaning of this statement?

Ans. We know, $n = \frac{c}{\upsilon}$ or $\upsilon = \frac{c}{n} = \frac{1}{2.42} \times c$

Then, speed of light in diamond is $\frac{1}{2.42}$ times the speed a light in vacuum.

Q.11 Define 1 dioptre of power of a lens.

Ans. Power = 1/f(in m)

Power of a lens in 1 dioptre if focal length of the lens is 1 metre of 100cm.

Q.12 A convex lens forms a real and inverted image of a needle at a distance of 50cm, from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also find the power of the lens.

Ans. (i) $\upsilon = 50\text{cm}$

$$m = \frac{h'}{h} = -1 \qquad [\because \text{ Image is real and inverted}]$$

$$\text{Also, } m = \frac{v}{\upsilon} \text{ or } u = -\upsilon = -50\text{m}$$

(ii) Using, $-\frac{1}{u}+\frac{1}{\upsilon}=\frac{1}{f}$, we get $\frac{1}{f}=\frac{1}{50}+\frac{1}{50}=\frac{2}{50}=\frac{1}{25}$ or $f = 25\text{cm}$

$$\therefore P = \frac{100}{f(\text{in cm})} = \frac{100}{25} = +4.0\text{D}$$

Thus needle is to be placed at 50cm in front of the lens.

Q.13 Find the power of a concave lens of focal length 2m.

Ans. Here $f = -2\text{m}$

$$\therefore P = \frac{1}{f} = -\frac{1}{2} = -0.5\text{D}$$

Q.,14 Which one of the following materials cannot be used to make a lens?

(A) Water (B) Glass (C) Plastic (D) Clay

Ans. (D). This is because clay is opaque (i.e. light cannot pass through it).

Q.15 The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(A) between the principal focus and the centre of curvature

(B) at the centre of curvature

(C) beyond the centre of curvature

(D) between the pole of the mirror and its principal focus

Ans. (D) between the pole of the mirror and its principal focus

Q.16 Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(A) at the principal focus of the lens

(B) at twice the focal length

(C) at infinity

(D) between the optical centre of the lens and its principal focus

Ans. (B), at twice the focal length

Q.17 A spherical mirror and a thin spherical lens have each a focal length of-IS cm. The mirror and the lens are likely to be

(A) both are concave

(B) both are convex

(C) the mirror is concave and the lens is convex

(D) the mirror is convex but the lens is concave

Ans. (A), both are concave

Q.18 No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

(A) plane only (B) concave only

(C) convex only (D) either plane or convex

Ans. (D) either plane or convex

Q.19 Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(A) a convex lens of focal length 50 cm

(B) a concave lens of focal length 50 cm

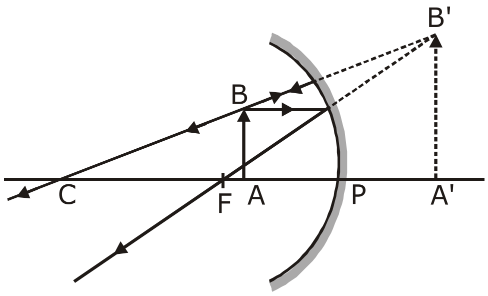
(C) a convex lens of focal length 5 cm

(D) a concave lens of focal length 5 cm

Ans. (C), Magnifying power of a reading glass (Convex lens) = $\frac{1}{f}$

Q.20 We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm.. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Ans. A concave mirror produces an erect image if the object is placed between the pole and the focus of the concave mirror. Thus, object may be placed at any position whose distance is less than 15 cm from the concave mirror. The image is virtual and erect. The image is larger than the object.



EXERCISE-I(Board Problems)

Q.1 If the magnification of a body of size 1 m is 2, what is the size of the image ? **(2003)**

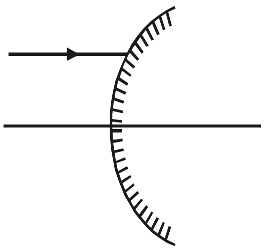
Q.2 What is the power of a concave lens of focal length 25 cm ? **(2004)**

Q.3 What will be the focal length of a lens whose power is given as +2.0 D ? **(2004)**

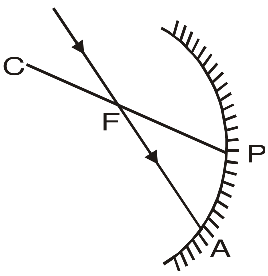
Q.4 Where will the image be formed by a concave mirror when an object is placed between the pole and the focus point of the mirror ? **(2005)**

Q.5 What is the value of focal length of a plane mirror ? **(2005)**

Q.6 A ray of light is incident on a convex mirror as shown in fig. Redraw the above diagram after completing the path of the light ray after reflection from the mirror. **(2006)**

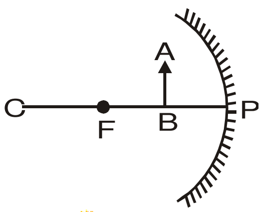


Q.7 Copy fig. in your answer book and show the direction of the light ray after reflection. **(2008)**

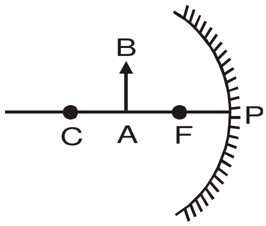


Q.8 The refractive index of diamond is 2.42. What is the meaning of this statement in relation to speed of light ? **(2008)**

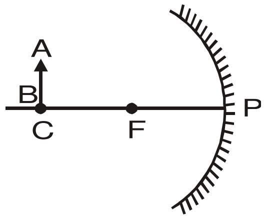
Q.9 Draw fig. in your answer book and show the formation of image of the object AB with the help of suitable rays.



Q.10 Draw fig. in your answer book and show the formation of image of the object AB with the help of suitable rays.



Q.11 Draw fig. in your answer book and show the formation of image with the help of suitable rays.



Q.12 Give the characteristics of image formed by a plane mirror. **(2003)**

Q.13 An object is placed at 0·06 m from a convex lens of focal length 0·1 m. Calculate the position of the image? **(2004)**

Q.14 An object is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position and nature of the image. **(2004)**

Q.15 Light enters from air into diamond, which has a refractive index of 2.42. Calculate the speed of light in diamond. The speed of light in air is 3×10^8 ms^{-1}. **(2005)**

Q.16 With the help of ray diagrams, show the formation of the images of an object by a concave mirror. When it is placed (i) beyond the centre of curvature (ii) at the centre of curvature. **(2005)**

Q.17 Draw ray diagrams to show the formation of image of an object by a concave mirror, when it is placed (i) between its centre of curvature C and focus F (ii) between pole P of mirror and its focus F. **(2005)**

Q.18 With respect to air, the refractive index of ice is 1·31 and that of rock salt is 1·54. Calculate the refractive index of rock salt w.r.t. ice. **(2005)**

Q.19 Draw ray diagrams to show the formation of image of an object by a concave lens when the object is placed. (i) at infinity (ii) between infinity and optical centre of the lens. **(2005)**

Q.20 Draw a ray diagram to show the position and nature of the image formed when an object is placed between focus F and pole P of a concave mirror. **(2006)**

Q.21 Draw ray diagrams to show the formation of the image of an object by a convex mirror, when it is placed (i) at infinity and (ii) between infinity and pole of the mirror. **(2006)**

Q.22 Draw a labelled ray diagram to locate the image of an object formed by a convex lens of focal length 20 cm when the object is placed 20 cm away from the lens.

Q.23 Explain with the help of a diagram, why a pencil partly immersed in water appears to be bent at the water surface. **(2008)**

Q.24 Draw the ray diagrams to represent the nature, position and relative size of the image formed by a convex lens for the object placed (i) at 2 F_1 (ii) between F_1 and optical centre O of the lens. **(2008)**

Q.25 Calculate the distance at which an object should be placed in front of a thin convex lens of focal length 10 cm to obtain a virtual image of double its size. **(2003)**

Q.26 A convex lens of focal length 40 cm is placed in contact with a concave lens of focal length 25 cm. What is the power the combination ? **(2003)**

Q.27 Find the position of an object, which when placed in front of a concave mirror of focal length 20 cm produces a virtual image, which is twice the size of the object. **(2003)**

Q.28 A concave lens made of a material of refractive index n_1 is kept in a medium of refractive index n_2. A parallel beam of light is incident on the lens. Complete the path of rays of light emerging from the concave lens if (i) $n_1 > n_2$ (ii) $n_1 = n_2$ (iii) $n_1 < n_2$. **(2003)**

Q.29 Find the position, nature and size of the image formed by a convex lens of focal length 20 cm of an object 4 cm high placed at a distance of 30 cm from it. **(2004)**

Q.30 A convex lens has focal length of 30 cm. Calculate at what distance should the object be placed from the lens so that it forms an image at 60 cm on the other side of the lens ? Find the magnification produced by the lens in this case. **(2004)**

Q.31 Find the position, nature and size of the image of an object 3 cm high placed at a distance of 9 cm from a concave of focal length 18 cm. **(2004)**

Q.32 An object 4 cm high is placed 40-0 cm in front of a concave mirror of focal length 20 cm. Find the distance from the mirror, at which a screen be placed in order to obtain a sharp image. Also find the size and nature of the image formed. **(2005)**

Q.33 An object is placed at a distance of 12 cm in front of a concave mirror. It forms a real image four times larger than the object. Calculate the distance of the image from the mirror.

Q.34 A 5.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal 20 cm. The distance of the object from the lens from the lens is 30 cm. By calculation, determine (i) the position (ii) the size of the image formed.

Q.35 An object 30 cm high is placed perpendicular to the principal axis of a concave lens of focal length 7.5 cm. The image is formed at a distance of 5.0 cm from the lens. Calculate (i) distance at which object is placed, and (ii) size and nature of image formed. **(2006)**

Q.36 A concave lens has focal length of 20 cm. At what distance from the lens a 5 cm tall object be placed so that it forms an image at 15 cm from the lens ? Also, calculate the size of the image formed. (Delhi, 2007)

Q.37 An object 50 cm tall is placed on the principal axis of a convex lens. Its 20 cm tall image is formed on the screen placed at a distance of 10 cm from the lens. Calculate the focal length of the lens.

EXERCISE-II

SECTION-A

- **Fill in the blanks**

1. A light wave of frequency 5×10^{14} Hz enters a medium of refractive index 1.5. In the medium the velocity of light wave is ___________ and its wavelength is ___________.

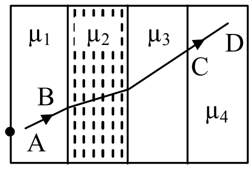
SECTION-B

- **Multiple choice question with one correct answers**

1. When a ray of light enters a glass slab from air.
(A) its wavelength decreases
(B) its wavelength increases
(C) its frequency decreases
(D) neither its wavelength nor its frequency changes

2. An eye specialist prescribes spectracles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination in diopters is
(A) +1.5 (B) −1.5 (C) +6.67 (D) −6.67

3. A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3 and μ_4 as shown in the figure.
The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have

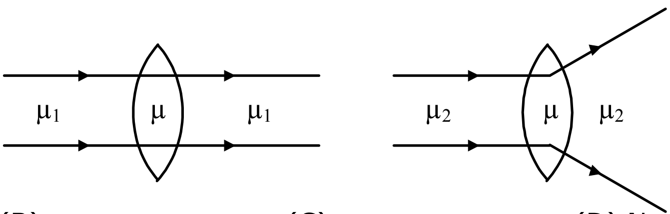


(A) $\mu_1 = \mu_2$ (B) $\mu_2 = \mu_3$ (C) $\mu_3 = \mu_4$ (D) $\mu_4 = \mu_1$

4. A hollow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices μ_1 and μ_2 respectively ($\mu_2 > \mu_1 > 1$). The lens will diverge a parallel beam of light if it is filled with
(A) air and placed in air (B) air and immersed in L_1
(C) L_1 and immersed in L_2 (D) L_2 and immersed in L_1

5. A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of virtual image from the surface is
(A) 6 cm (B) 4 cm (C) 12 cm (D) 9 cm

6. What is the relation between the refractive indices μ_1 and μ_2 , if the behaviour of light ray is as shown in the figure.



(A) $\mu_1 > \mu_2$ (B) $\mu_1 < \mu_2$ (C) $\mu_1 = \mu_2$ (D) None of these

7. Which of the following lens can form image of an object on screen.
(A) Concave (B) Convex
(C) Both convex and concave (D) none of these

8. To obtain a dimnished image of an object, formed by a convex lens, where should the object must be placed?
(A) between F and 2F (B) At F (C) between infinity and 2F (D) at 2F

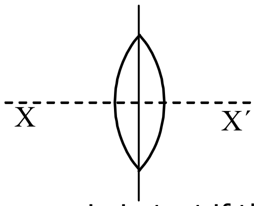
9. If object is placed between infinity and 2F of a convex lens, then image will form
(A) at F (B) between F and 2F (C) at 2 F (D) at infinity

SECTION-C

- **Assertion & Reason**

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.
(A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'
(B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'
(C) Assertion is true but Reason is false
(D) Assertion is false but Reason is true

1. **Assertion:** A ray of light entering from glass to air suffers from change in frequency.
Reason: Velocity of light in glass is less than that in air
2. **Assertion:** A plane mirror has unity magnification.
Reason: In the case of plane mirror the distance of image is equal to the distance of object
3. **Assertion:** Convex mirror is used as a driver's mirror.
Reason: Field view of a convex mirror is large.
4. **Assertion:** Focal length of a lens remain same if it is cut across the axis along XX´.



Reason: Both the refracting surfaces remain in tact if the lens is cut along X – X´ plane.
5. **Assertion:** Power of a lens is indirectly proportional to its focal length.
Reason: Units of focal length and power of a lens are same.

SECTION-D

- **Match the following (one to one)**

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the same entries of column-II and one entry of column-II Only one matching with entries of column-I

1.

Column I	**Column II**
(A) Law of reflection	(P) 1/focal length
(B) Law of refraction	(Q) i = r
(C) Power of lens	(R) $\frac{\sin i}{\sin r} = \text{constant}$
(D) Absolute refractive index of glass	(S) $\frac{\text{Speed of light in air}}{\text{Speed of light in glass}}$

EXERCISE-III

SECTION-A

- **Multiple choice question with one correct answers**

1. A convex lens A of focal length 20 cm and a concave lens B of focal length 5 cm are kept along the same axis with a distance 'd' between them. If a parallel beam of light falling on a leaves B as a parallel beam, then d is equal to
(A) 25 cm (B) 20 cm (C) 15 cm (D) 10 cm
2. A thin rod of length f/3 is placed along the principal axis of a concave mirror of focal length f such that

its image which is real and elongated, just touches the rod. The magnification is

(A) 2/3 (B) 3/2 (C) 3/5 (D) 5/3

3. Two thin lenses, when in contact, produce a combination of power +10 diopters. When they are 0.25 m apart, the power reduces to +6 diopters. The focal length of the lenses are

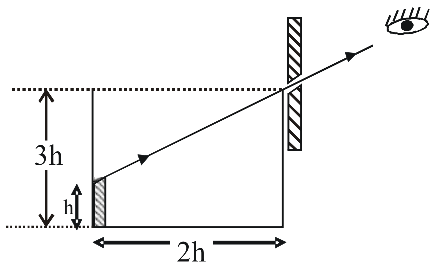
(A) 0.125 m. 0.5 m (B) 0.25 m, 0.5 m (C) 0.25 m, 0.75 m (D) none of these

4. A diminished image of an object is to be obtained on a screen 1.0 m from it. This can be achieved by appropriately placing.

(A) A convex lens of focal length more than 0.25 m(B) A convex mirror of suitable focal length

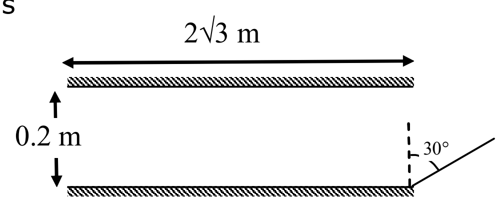
(C) A convex lens of focal length less than 0.25 m (D) A concave lens of suitable focal length

5. An observer can see through a pin-hole the top end of a thin rod of height h, placed as shown in the figure. The beaker height is 3h and its radius h. When the beaker is filled with a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is



(A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$ (C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$

6. Two plane mirrors A and B are aligned parallel to each other as shown in the figure. A light ray is incident at an angle 30° at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is



(A) 28 (B) 30 (C) 31 (D) 34

7. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the convex lens, calculate the new size of the image.

(A) 1.25 cm (B) 1.67 cm (C) 1.05 cm (D) 2 cm

8. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length is 2/3. Their equivalent focal length is 30 cm. What are their individual focal lengths?

(A) −15, 10 (B) −10, 15 (C) 75, 50 (D) −75, 50

9. A short linear object of length b lies along the axis of a concave mirror of focal length f at a distance u from the pole of the mirror. The size of the image is approximately equal to

(A) $b\left(\frac{u-f}{f}\right)^{1/2}$ (B) $b\left(\frac{f}{u-f}\right)^{1/2}$ (C) $b\left(\frac{u-f}{f}\right)$ (D) $b\left(\frac{f}{f-u}\right)^{2}$

10. A concave mirror is placed on a horizontal table, with its axis directed vertically upwards. Let O be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image also located at C. If the mirror is now fillect with water, the image will be

(A) real, and will remain at C (B) real, and located at a point between C and ∞.

(C) virtual, and located at a point between C and O. (D) real, and located at a point between C and O.

SECTION-B

- **Multiple choice question with one or more than one correct answers**

1. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by

an opaque screen.
(A) half the image will disappear (B) complete image will be formed
(C) intensity of the image will increase (D) intensity of the image will decrease

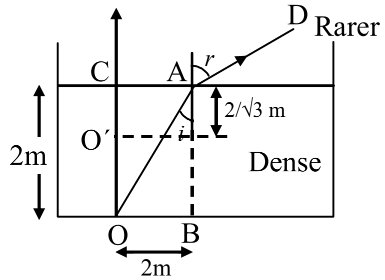
2. Which of the following form(s) a virtual and erect image for all positions of the object?
(A) convex lens (B) concave lens (C) convex mirror (D) concave mirror

SECTION-C

• **Comprehension**

An object O is placed in denser medium. A light ray OA travels from denser to rarer medium. Refracted ray AD appears to come from O´. O´ is image of the object O.

Given that: OC = 2m, O´C = 2m/√3 and OB = 2m.



1. Value of sin *i* is
(A) 60° (B) 45° (C) 30° (D) None of these

2. Value of sin *r* is
(A) 60° (B) 45° (C) 30° (D) None of these

3. Refractive index of rarer medium w.r.t. denser medium is
(A) $\frac{\sin i}{\sin r}$ (B) $\frac{\sin r}{\sin i}$ (C) $\frac{\sin (i-r)}{\sin r}$ (D) None of these

4. Refractive index of denser medium w.r.t. rarer medium is
(A) $\frac{\sin i}{\sin r}$ (B) $\frac{\sin r}{\sin i}$ (C) $\frac{\sin (i-r)}{\sin r}$ (D) None of these

SECTION-D

• **Match the following (one to many)**

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

1.

Column I	Column II
(A) Straight line which is normal to the mirror at its pole (p)	(P) will passes through principal focus (F)
(B) A ray, parallel to the principal axis of concave mirror after reflection	(Q) Focal length (f)
(C) The distance between the pole and the principle focus of a mirror	(R) principal axis
(D) A straight line passing through the pole (p) and the centre of curvature (c)	(S) Half of radius of curvature (c)

EXERCISE-IV

Q.1 A mirror forms a virtual image of a real object.

(A) It must be a convex mirror.

(B) It must be a concave mirror.

(C) It must be a plane mirror.

(D) It may be any of the mirrors mentioned above.

Q.2 The angle of incidence is the angle between

(A) the incident ray and the surface of the mirror

(B) the reflected ray and the surface of the mirror

(C) the normal to the surface and the incident ray

(D) the normal to the surface and the reflected ray

Q.3 The angle of reflection is the angle between

(A) the incident ray and the surface of the mirror

(B) the reflected ray and the surface of the mirror

(C) the normal to the surface and the incident ray

(D) the normal to the surface and the reflected ray

Q.4 An object is placed at the centre of curvature of a concave mirror. The distance between its image and the pole is

(A) equal to f

(B) between f and 2f

(C) equal to 2f

(D) greater than 2f

Q.5 An object of size 2.0 cm is placed perpendicular to the principal axis of a concave mirror. The distance of the object from the mirror equals the radius of curvature. The size of the image will be

(A) 0.5 cm (B) 1.5 cm

(C) 1.0cm (D) 2.0 cm

Q.6 The magnification m of an image formed by a spherical mirror is negative. It means, the image is

(A) smaller than the object

(B) larger than the object

(C) erect

(D) inverted

Q.7 A point object is placed on the principal axis of a spherical mirror. The object-distance u is

(A) definitely negative

(B) definitely positive

(C) positive if the object is to the left of the centre of curvature

(D) positive if the object is to the right of the centre of curvature

Q.8 $f = \frac{R}{2}$ is valid

(A) for convex mirrors but not for concave mirrors

(B) for concave mirrors but not for convex mirrors

(C) for both convex and concave mirrors

(D) neither for convex mirrors nor for concave mirrors

Q.9 A ray of light is incident on a concave mirror. If it is parallel to the principal axis, the reflected ray will

(A) pass through the focus

(B) pass through the centre of curvature

(C) pass through the pole

(D) retrace its path

Q.10 If an incident ray passes through the centre of curvature of a spherical mirror, the reflected ray will

(A) pass through the pole

(B) pass through the focus

(C) retrace its path

(D) be parallel to the principal axis

Q.11 To get an image larger than the object, one can use

(A) a convex mirror but not a concave mirror

(B) a concave mirror but not a convex mirror

(C) either a convex mirror or a concave mirror

(D) a plane mirror

Q.12 A ray of light travelling in air falls obliquely on the surface of a calm pond. It will

(A) go into the water without deviating from its path

(B) deviate away from the normal

(C) deviate towards the normal

(D) turn back on its original path

Q.13 A ray of light goes from a medium of refractive index μ_1 to a medium of refractive index μ_2. The angle of incidence is i and the angle of refraction is r. Then, sin i/sin r is equal to

(A) μ_1 (B) μ_2

(C) $\frac{\mu_1}{\mu_2}$ (D) $\frac{\mu_2}{\mu_1}$

Q.14 A thin lens and a spherical mirror have a focal length of + 15 cm each.

(A) Both are convex.

(B) The lens is convex and the mirror is concave.

(C) The lens is concave and the mirror is convex.

(D) Both are concave.

Q.15 A convex lens

(A) is thicker at the middle than at the edges

(B) is thicker at the edges than at the middle

(C) has uniform thickness everywhere

(D) is called a diverging lens

Q.16 A convex lens forms a virtual image when an object is placed at a distance of 18 cm from it. The focal length must be

(A) Greater than 36 cm

(B) Greater than 18 cm

(C) Less than 36 cm

(D) Less than 18 cm

Q.17 An object is placed before a convex lens. The image formed

(A) is always real

(B) may be real or virtual

(C) is always virtual

(D) is always erect

Q.18 An object is placed before a concave lens. The image formed

(A) is always erect

(B) may be erect or inverted

(C) is always inverted

(D) is always real

Q.19 A lens has a power of +0.5 D. It is

(A) a concave lens of focal length 5 m

(B) a convex lens of focal length 5 cm

(C) a convex lens of focal length 2 m

(D) a concave lens of focal length 2 m

Q.20 A deviation in the path of a ray of light can be produced

(A) by a glass prism but not by a rectangular glass slab

(B) by a rectangular glass slab but not by a glass prism

(C) by a glass prism as well as a rectangular glass slab

(D) neither by a glass prism nor by a rectangular glass slab

Q.21 If you want to see your full image then the, minimum size of the plane mirror

(A) should be of your height.

(B) should be half of your height.

(C) should be twice of your height.

(D) depends upon your distance from the mirror.

Q.22 An object A is placed at a distance d in front of a plane mirror. If one stands directly behind the object at a distance S from the mirror, then the distance of the image.of A from the individual is

(A) 2 S (B) 2 d

(C) S + d (D) S + 2d

Q.23 A light bulb is placed between two plane mirrors inclined at an angle of 60°. The number of images formed are

(A) 6 (B) 5

(C) 4 (D) 2

Q.24 A person of height 1.8 standing at the centre of a room having equal dimensions of 10 m wishes to see the full image of the back wall in the mirror fixed on the front wall. The minimum height of the plane mirror needed for this purpose is

(A) 0.9 m (B) 1.8 m

(C) $\frac{10}{3}$ m (D) 10 m

Q.25 Two plane mirrors inclined at an angle to one another have an object placed between them. If five images of the object are observed, the maximum possible angle between the mirrors is

(A) 45° (B) 60°

(C) 72° (D) 90°

Q.26 In case of a thick plane mirror multiple images are formed. The brightest of all the images will be

(A) first (B) second

(C) third (D) fourth

Q.27 Indicate the only correct statement.

(A) The image formed by a convex mirror can be taken on the screen.

(B) A convex mirror can produce a parallel beam of light from a point source. .

(C) The image of an object placed at the focus of a convex mirror will be formed at infinity.

(D) A concave mirror can never form a diminished virtual image.

Q.28 The focal length of a concave mirror is f and the distance from the object to the principal focus is x. The magnification obtained will be

(A) (f + x)/f (B) f/x

(C) $\frac{\sqrt{f}}{\sqrt{x}}$ (D) f^2/x^2

Q.29 In a museum a child walks towards a large concave mirror. He will see that

(A) his real, erect image goes on decreasing in size.

(B) his virtual, erect image goes on increasing in size.

(C) his real, inverted image goes on increasing in size and suddenly it becomes virtual, erect and magnified.

(D) his real, erect Image goes on diminishing in size and suddenly it becomes virtual, erect and magnified.

Q.30 The magnification of an object placed 10 cm from a convex mirror of radius of curvature 20 cm will be

(A) 0.2 (B) 0.5

(C) 1 (D) infinity

Q.31 A concave mirror of focal length 10 cm produces an image five times as large as the object. If the image is in front of the mirror, the distance of the object from the mirror will be

(A) 10 cm (B) 12 cm

(C) 16 cm (D) 20 cm

Q.32 To form an image twice the size of the object, using a convex lens of focal length 20 cm, the object distance must be –

(A) < 20 cm

(B) > 20 cm

(C) < 20 cm and between 20 cm and 40 cm

(D) Cannot say

Q.33 Refractive index of glass w.r.t. air is 3/2. What is the refractive index of air w.r.t glass?

(A) 2/3 (B) 1

(C) Zero (D) $(3/2)^2$

Q.34 The mirage is formed due to

(A) reflection

(B) refraction

(C) total internal reflection

(D) dispersion

Q.35 A glass prism has refractive index 1.5 and the refracting angle 90° If a ray falls on it at an angle of incidence of 30°, then the angle of emergence will be

(A) 60°

(B) 45°

(C) 30°

(D) the ray will not emerge at all

Q.36 When monochromatic light passes from vacuum to a material medium and vice versa; which of the following characteristics of light beam does not change?

(A) velocity (B) intensity

(C) wavelength (D) frequency

Q.37 A piece of glass when immersed in a transparent solution of refractive index 1.48 becomes almost invisible. The refractive index of glass used is

(A) zero (B) 1

(C) 1.48 (D) infinite

Q.38 Which of the following conditions are necessary for total internal reflection to take place at the boundary of two optical media?

I. Light is passing from optically denser medium to optically rarer medium.

II. Light is passing from optically rarer medium to optically denser medium.

III. Angle of incidence is greater than the critical angle.

IV. Angle of incidence is less than the critical angle.

(A) I and III only (B) II and IV only

(C) III and IV only (D) I and IV only

Q.39 The speed of light in vacuum is 3.0×10^8m/s. If the refractive index of a transparent liquid is 4/3, then the speed of light in the liquid is

(A) 2.25×10^8 m/s

(B) 3×10^8 m/s

(C) 4×10^8 m/s

(D) 4.33×10^8 m/s

Q.40 The refractive indices of water and glass are 4/3 and 3/2 respectively. The refractive index of water with respect to glass is

(A) $\frac{8}{9}$ (B) 2

(C) $\frac{2}{3}$ (D) $\frac{1}{6}$

Q.41 Which of the following can be used to form a virtual image of an object?

I. convex lens

II. concave lens

III. concave mirror

(A) II only (B) II and III only

(C) I and III only (D) I, II and III

Q.42 An object is placed in front of a concave mirror focal length f. An erect image is formed with a magnification of 2. To obtain real image with the same magnification, the object has to be moved through a distance of: **[NTSE]**

(A) f/2 (B) f

(C) 3f/2 (D) 2f/3

Q.43 A girl standing in front of a vertical plane mirror, is able to see herself only upto her knees. She can see the lower part of her legs, if:-**[NTSE]**

(A) she moves towards the mirror

(B) she moves away from the mirror

(C) she bends down

(D) she stands on a stool

Q.44 Image of an object in a concave mirror is observed on a screen first by keeping the object at position A and then at another position B. The magnifications m_A and m_B in the two cases were determined. If $m_A m_B = 1$, then: **[NTSE]**

(A) both the position A and B are beyond the centre of curvature C.

(B) both the position A and B are between C and F.

(C) one of the position A and B is between pole P and focus F of the mirror.

(D) one of the positions A and B is between F and C while the other is beyond C.

Q.45 Light incident on a rotating mirror M is returned to a fixed mirror N placed 22.5 km away from M. The fixed mirror reflects it back to M (along the same path) which in turn reflects the light again along a direction that makes an angle of 27° with the incident direction. The speed of rotation of the mirror is: **[NTSE]**

(A) 250 revolutions s^{-1}

(B) 500 revolutions s^{-1}

(C) 1000 revolutions s^{-1}

(D) 125 revolutions s^{-1}

Q.46 Which of the following phenomena can be demonstrated by light. But not with sound waves in an air column? **[NTSE]**

(A) Reflection (B) Diffraction

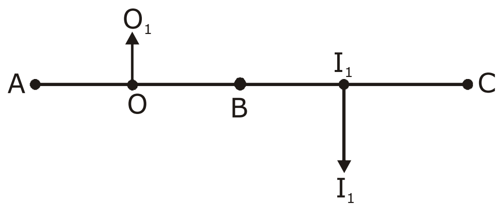
(C) Refraction (D) Polarization

Q.47 An object is place at a distance x_1 from the focus of a concave mirror. Its real image is formed at a distance x_2 from the focus. Hence, the focal length of the mirror is: **[NTSE]**

(A) $\frac{x_1 x_2}{x_1 + x_2}$ (B) $\sqrt{x_1 x_2}$

(C) $\frac{x_1 + x_2}{2}$ (D) $|x_1 - x_2|$

Q.48 In the figure shown below. A, B, C are points on the principal axis of a spherical mirror/lens. Which of the following arrangements will produce image I I_1 of the object O O_1? **[NTSE]**



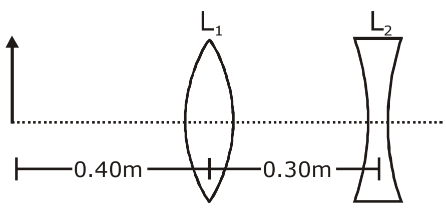
(A) a convex mirror at A

(B) a concave mirror at C

(C) a concave mirror at A

(D) a concave lens at B

Q.49 An object is placed 0.40m from one of the two lenses L_1 and L_2 of focal length 0.20m and 0.10m respectively as depicted in the figure. The separation between the lenses is 0.30m.



The final image formed by this two lens system is at **[NTSE]**

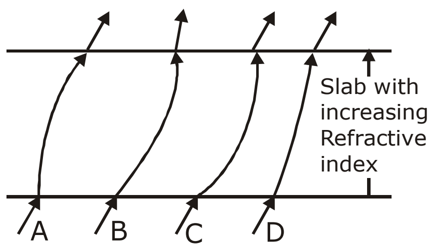
(A) 0.13 m to the right of the second lens

(B) 0.05 m to the right of the second lens

(C) 0.13 m to the left of the second lens

(D) Infinity

Q.50 A ray of light enters a slab of material with increasing refractive index. Four possibilities of the trajectory of the ray are shown below.

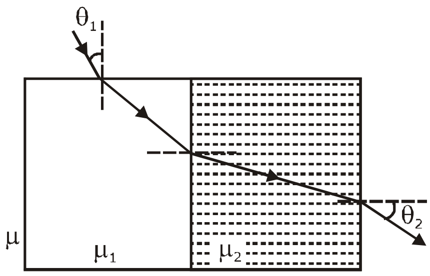


The correct choice is: **[NTSE]**

(A) A (B) B

(C) C (D) D

Q.51 In the figure below a ray of light travelling in a medium of refractive index μ passes through two different connected rectangular blocks of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$).**[NTSE]**



The angle of incidence θ_1 is increased slightly. Then angle θ_2.

(A) increases

(B) decreases

(C) remains the same

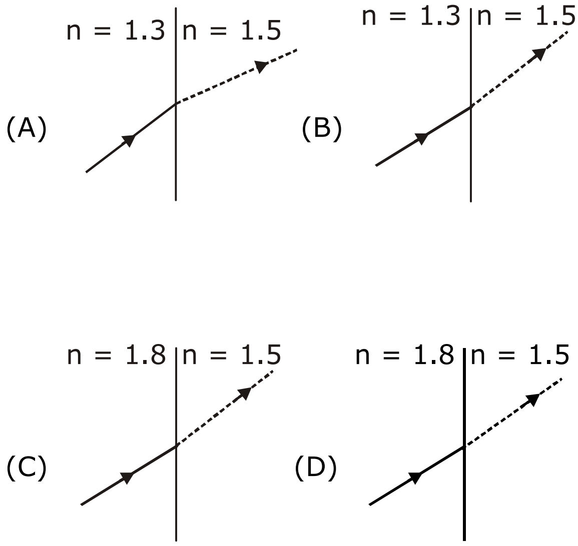
(D) increases or decreases depending on the value of (μ_1/μ_2).

Q.52 A light source is placed 100cm away from a screen. A converging lens placed at a certain position between the source and the screen focuses the image of the source on the screen. The lens is moved a distance of 40cm and it is found that it again focuses the image of the source on the screen. The focal length of the lens is: **[NTSE]**

(A) 21 cm (B) 30 cm

(C) 40 cm (D) 67 cm

Q.53 Which of the following does NOT represent correct refraction? **[NTSE]**



Answers

EXERCISE-II

SECTION-A

1. 2×10^8 m/s, 0.4×10^{-6} m

SECTION-B

1.	(A)	2.	(B)	3.	(D)	4.	(D)	5.	(B)	6.	(B)
7.	(B)	8.	(C)	9.	(B)						

SECTION-C

1.	(D)	2.	(A)	3.	(A)	4.	(A)	5.	(C)

SECTION-D

1. (A)-(Q), (B)-(R), (C)-(P), (D)-(S)

EXERCISE-III

SECTION-A

1.	(C)	2.	(B)	3.	(A)	4.	(C)	5.	(B)	6.	(C)
7.	(B)	8.	(A)	9.	(D)	10.	(D)				

SECTION-B

1.	(B,D)	2.	(B,C)

SECTION-C

1.	(B)	2.	(A)	3.	(A)	4.	(B)

SECTION-D

1. (A)-(R), (B)-(P), (C)-(Q,S), (D)-(P,R)

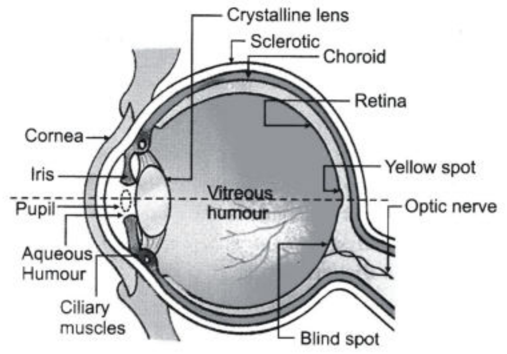
EXERCISE-IV

1.	D	**2.**	C	**3.**	D	**4.**	C	**5.**	D	**6.**	D	**7.**	A
8.	C	**9.**	A	**10.**	C	**11.**	B	**12.**	C	**13.**	D	**14.**	A
15.	A	**16.**	B	**17.**	B	**18.**	A	**19.**	C	**20.**	A	**21.**	B
22.	C	**23.**	B	**24.**	C	**25.**	C	**26.**	B	**27.**	D	**28.**	B
29.	C	**30.**	B	**31.**	B	**32.**	C	**33.**	A	**34.**	C	**35.**	D
36.	D	**37.**	C	**38.**	A	**39.**	A	**40.**	A	**41.**	D	**42.**	B
43.	B	**44.**	D	**45.**	A	**46.**	D	**47.**	B	**48.**	C	**49.**	D
50.	C	**51.**	B	**52.**	A	**53.**	B						

HUMAN EYE

THE HUMAN EYE

The construction and working of the human eye is similar to photographic camera in many respects. Human eye is almost a spherical ball, with a light bulge in the front. The structure and function of each part of the eye is given below :



Human Eye

- **Sclerotic :** It is the outermost covering of the eye ball. It is made of white tough fibrous tissues. *Its function is to house and protect the vital internal parts of the eye.*
- **Cornea :** It is the front bulging part of the eye. It is made of transparent tissues. *Its function is to act as a window to the world, i.e., to allow the light to enter in the eye ball.*
- **Choroid :** It is a grey membrane attached to the sclerotic from the inner side. *Its function is to darken the eye from inside and, hence, prevent any internal reflection.*
- **Optic Nerve :** It is a bundle of approximately 70,000 nerves originating from the brain and entering the eye ball from behind. *Its function is to carry optical messages (visual messages) to the brain.*
- **Retina :** The optic nerve on entering the ball, spreads like a canopy, such that each nerve end attaches itself to the choroid. The nerve endings form a hemi-spherical screen called retina. These nerve endings on the retina are sensitive to visible light. On retina there are two important areas namely yellow spot and Blind spot. *The function of retina is to receive the optical image of the object and then convert it to optical pulses. These pulses are then sent to the brain through optic nerve.*
- **Yellow spot :** It is a small area, facing the eye lens. It has high concentration of nerve endings and is slightly raised as well as slightly yellow in colour. *Its function is to form a very clear image by sending a large number of optical pulses to brain.*
- **Blind Spot :** It is a region on the retina, where the optic nerve enters the eye ball. It has no nerve ending and hence, is insensitive to light. *It does not seem to have any function. Any image formed on this spot is not visible.*
- **Crystalline lens :** It is a double convex lens made of transparent tissues. It is held in position by a ring of muscles, commonly called ciliary muscles. *Its function is to focus the images of different objects clearly on the retina.*
- **Ciliary Muscles :** It is a ring of muscles which holds the crystalline lens in position . When these muscles relax, they increase the focal length of the crystalline lens and vice versa. *Its function is to alter the focal length of crystalline lens so that the images of the objects, situated at different distances, are clearly focused on the retina.*
- **Iris :** It is a circular diaphragm suspended in front of the crystalline lens. It has a tiny hole in the middle and is commonly called **pupil.** It has tiny muscles arranged radially around the pupil. These muscles can increase or decrease the diameter of the pupil. The iris is heavily. pigmented. The colour of eyes depends upon colour of pigment.

The function of iris is to control the amount of light entering the eye. This is done by increasing or decreasing the diameter of pupil

- **Vitreous Humour :** It is a dense jelly-like fluid, slightly grey in colour, filling the part of eye between crystalline lens and retina.
  Its function is (i) to prevent the eye ball from collapsing due to change in atmospheric pressure, (ii) in focusing the rays clearly on the retina.

- **Aqueous Humour :** It is a watery, saline fluid, filling the part of the eye between the cornea and the crystalline lens.
  Its function is (i) to prevent front part of the eyeball from collapsing with the change in atmospheric pressure, (ii) to keep the cornea moist.

Newton's Thought

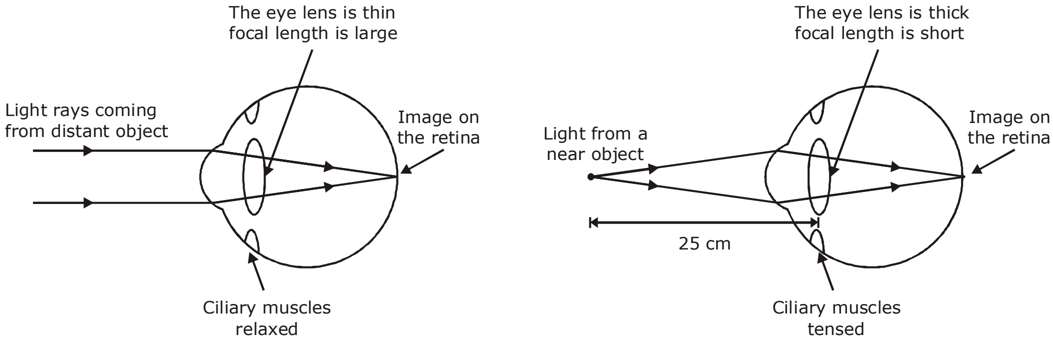
RODS AND CONES CELLS: The cells on the retina are of two shapes: rod-shaped and cone shaped. The rod cells of our retina respond to the intensity of light. While cone shaped cells respond to colours. It should be noted that animals may differ from human beings in their colour perception. For example, the bee has some cone shaped cells in the retina of its eye which enable it to see colours beyond indigo and violet parts of the spectrum which is called ultraviolet region. We cannot see colours beyond indigo and violet so we are said to be ultraviolet blind.

YELLOW SPOT: The most sensitive point on the retina is called the yellow spot. It is situated at the centre of the retina and is lightly raised. It has a little depression called fovea-centralis, which is extremely sensitive to light. Its function is to form an extremely clear image.

BLIND SPOT: The least sensitive point is known as the blind spot. There are no rods and cones at the point where optic nerves leave the eyeball to go to the brain.

POWER OF ACCOMMODATION OF THE EYE

When the object is infront of eye then light rays coming from the object are refracted and after passing through the vitreous humour they are focused on the retina. The sensation from retina is conveyed to the brain through the optic nerves and the object becomes visible.



When eye is in normal condition i.e. the muscles are not strained then a clear image of the objects situated at infinity is formed on the retina. This is possible only when the distance between lens and retina is equal to the focal length of the lens(fig). When the object is close to the eye then its image should be formed behind the retina and it should by blurred, but it is not so in reality. Because when the object is close to eye then muscles are strained automatically. Muscles get contracted to make lens thicker at the centre which reduces the focal length of the lens and image is again formed on the retina. **The ability of self adjustment of focal length of the eye lens is called accommodation power.**

DEFECTS OF VISION AND THEIR CORRECTION

Abnormalities in the normal vision of the eye are called defects of vision or defects of eyes.

The most commonly observed defects of vision (or defects of eyes) are:

(i) Myopia or shortsightedness or nearsightedness

(ii) Hypermetropia or longsightedness or hyperopia or farsightedness

(iii) Astigmatism

SHORTSIGHTEDNESS (OR MYOPIA)

Shortsightedness (or myopia) is the defect due to which the eye is not able to see the distant objects clearly though it can see the nearby objects clearly.

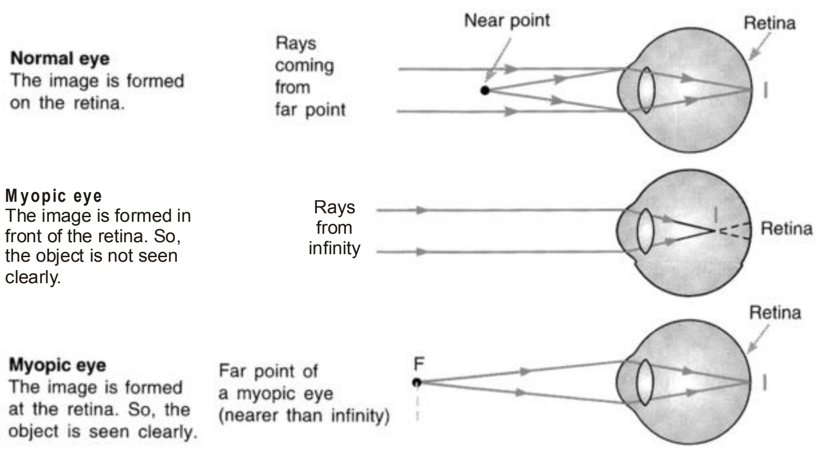
So, a shortsighted or myopic eye has its far point nearer than infinity.

WHAT CAUSES SHORTSIGHTEDNESS (OR MYOPIA)

Myopia or shortsightedness is caused by the following reasons.

(a) Decrease of focal length of the eye lens, i.e. the eye lens becomes more convergent.

(b) Elongation of the eyeball, i.e. the increased length of the eyeball.



A normal and a shortsighted (or myopic) eye

How is shortsightedness (or myopia) corrected ?

The shortsightedness (myopia) can be corrected by making the eye lens less convergent. This can be done by placing a concave lens (divergent lens) of suitable focal length before the eye lens.

The rays of light coming from a distant object after passing through the concave (diverging) lens of the spectacles diverge slightly. As a result, the rays entering the eye appear to come from the far point of the myopic eye, and therefore get focused at the retina to form a clear image.

How to calculate the focal length and power of the lens used for correcting a myopic eye

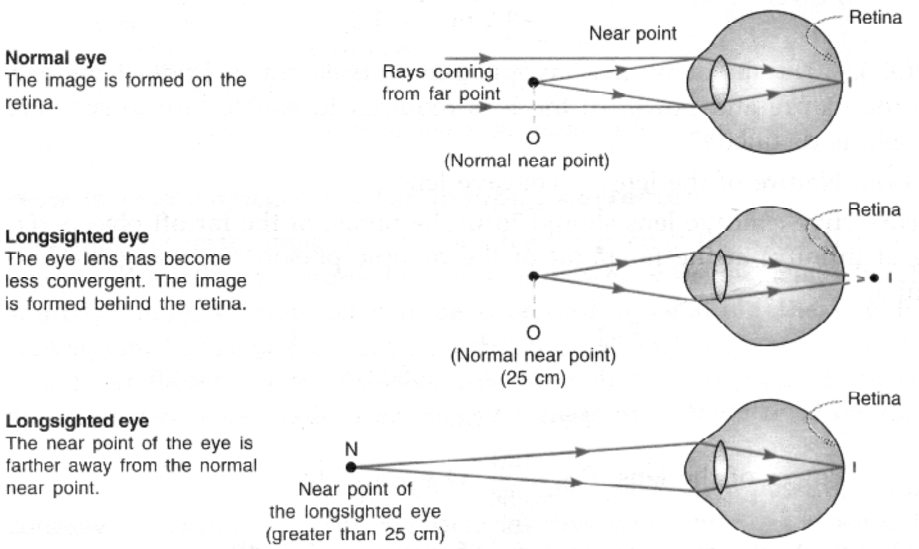
The corrective lens (concave lens) needed to correct a myopic eye should form the image of the far-off object (e.g. at infinity) at the far point (d) of the myopic person.

Thus, $u = -\infty$, $v = -d$, $f = ?$

$$\therefore \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{d} \quad \Rightarrow \quad f = -d$$

LONGSIGHTEDNESS (OR HYPERMETROPIA OR HYPEROPIA)

The longsightedness (or hypermetropia) is the defect due to which the eye is not able to see clearly the nearby objects though it can see the distant objects clearly.
So, a longsighted eye has its near point farther away from the normal near point (about 25 cm for an adult).



Focussing of light rays by a longsighted eye

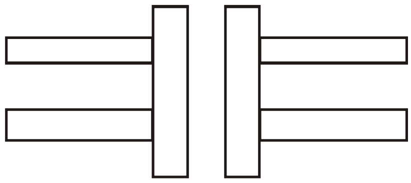
WHAT CAUSES LONGSIGHTEDNESS (OR HYPERMETROPIA)
Hypermetropia or longsightedness is caused due to the following reasons:
(i) Increase of the focal length of the eye lens, i.e. the eye lens becoming less convergent.
(ii) Shortening of the eye ball, i.e. the length of the eye ball has decreased.

HOW IS LONGSIGHTEDNESS (OR HYPERMETROPIA) CORRECTED
Longsightedness (hypermetropia) can be corrected by making the eye lens more convergent. This is generally done by placing a convex lens (converging lens) of suitable focal length before the eye lens. This is shown in Fig.
The rays from a nearby object (about 25 cm) after passing through the convex lens of the spectacles converge slightly. As a result, the rays entering the eye appear to come from the near point of the longsighted eye, and therefore get focused at the retina to form a clear image.
How to calculate the focal length and power of the lens used for correcting a hypermetropic eye
The corrective lens (a convex lens) needed to correct a hypermetropic (or longsighted) eye should form the image of the object placed at the normal near point (the least distance of distinct vision is 25 cm) at the near point of the hypermetropic person. Thus,
v = Near point distance of the hypermetropic eye = – d
u = Near point distance for the normal eye = – D = – 25 cm Using the lens formula,

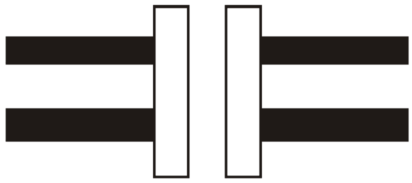
$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-d}-\frac{1}{25\,\text{cm}}$$

ASTIGMATISM

This defect arises due to different sections of cornea having different radii of curvature. One section of cornea may be more sharply curved that the other. The man cannot focus on both horizontal and vertical line simultaneously.
For remedy a cylindrical lens with the axis of the cylindrical lens parallel to the correct axis of the cornea, is used.



Normal eye

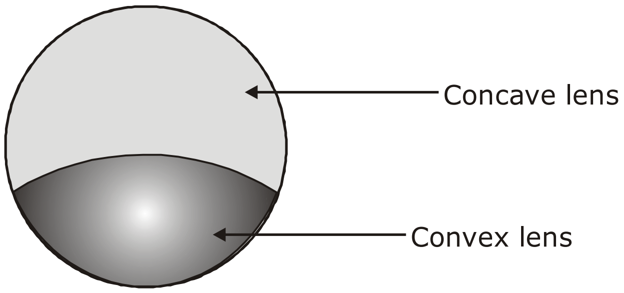


Astigmatic eye

If along with astigmatism, myopia or hypermetropia is also associated, which is generally very common, then for the complete remedy of the defect, sphero-cylindrical (or compound) lens are used.
Eye with this defect is unable to see the lines in different axes but at the same distance with same clarity. It occurs due to irregular curvature of cornea/by birth or arises due to some injury. Horizontal and vertical lines can't be seen simultaneously with this defective eye. Object in one direction get well focused and in perpendicular direction remain blurred.
Correction: In this case, the spectacles are cylindrical lenses of suitable focal length.

PRESBYOPIA

This defect is usually found in older persons. Due to stiffening of ciliary muscles, controlling the curvature of the lens reduces, thus the eye loses much of its accommodating power.
As a result distant as well as nearby objects cannot be seen clearly in proper perspective. That is, in this defect near point as well as far point of the eye is affected. For the remedy of this defect two separate lenses or one bifocal lens is used. For visualizing nearby objects, convex lens is used, where as for seeing distant objects concave lens is used.



Presbyopia

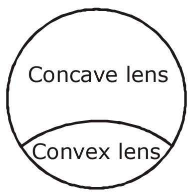
Newton's Thought

PRESBROPIA:
It is purely an old age problem due to which the person cannot see near by object clearly. In other words, Presbyopia is old age hypermetropia.

Cause
In old age, the ciliary muscles become stiff, and hence, they do not contract. This they are unable to make the crystalline lens thicker, with the result that the focal length of the crystalline lens does not decrease as desired. Thus, the image of the object situated at the least distance of distinct vision is formed behind the retina.

Correction: Same as in the case of hypermetropia.

Note: Some times a person who already had myopia at younger age, may suffer from presbyopia at old age. Such persons overcome this by using bifocal lens as shown:

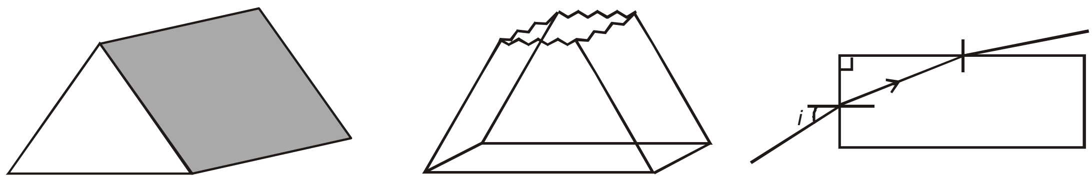


To rectify long sightedness, glasses fitted with convex lenses are used and for short sightedness, glasses fitted with concave lenses are used.

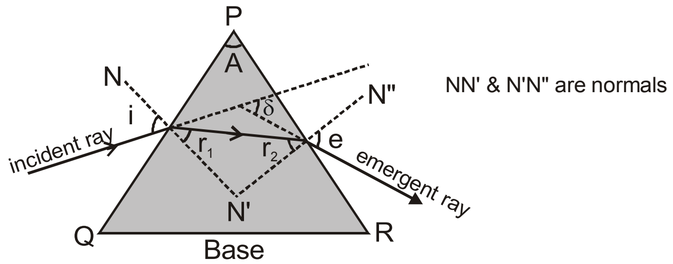
PRISM

A homogeneous solid transparent and refracting medium bounded by two plane surfaces inclined at an angle is called a prism :

3-D View



Refraction through a prism :



(a) PQ and PR are refracting surfaces.

(b) $\angle QPR = A$ is called refracting angle or the angle of prism (also called Apex angle.)

(c) δ = angle of deviation

(d) For refraction of a monochromatic (single wave length) ray of light through a prism;

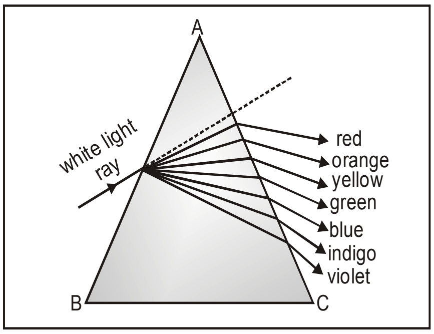
$\delta = (i + e) - (r_1 + r_2)$ and $r_1 + r_2 = A$

$\therefore$ $\delta = i + e - A$.

DISPERSION OF WHITE LIGHT

Sir Isaac Newton, while working with an astronomical telescope, observed that the images of stars as seen through the telescope were coloured near the fringes. He got the lenses of the telescope polished, but found that the colour still persisted. From the above observation, he concluded that the fault may not be with the lenses, but it had something to do with the nature of light itself. To investigate this conclusion, he performed the following experiment.

Experiment: Newton allowed sunlight to enter through a small hole in a window of a darkened room. He placed an equilateral prism in the path of the narrow beam of light. The light emerging from the prism was allowed to fall on the white screen. It was found that light received on the white screen was a band of seven colours. The order of colours from the base of prism is violet, indigo, blue, green, yellow, orange and red. This order of colours can be easily remembered by remembering the word VIBGYOR.



DEFINITIONS

(a) **Dispersion :** The phenomenon due to which white light splits into seven colours (VIBGYOR), when passed through an equilateral prism is called **dispersion**.

(b) **Spectrum:** The band of seven colours obtained on the screen, when white light splits into seven colours is called **spectrum**.

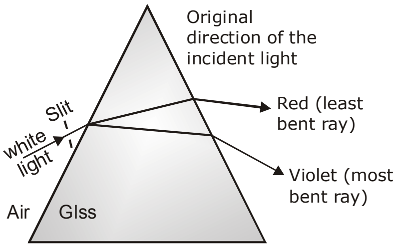
What is meant by monochromatic and polychromatic light

The light of one single colour, or of one single wavelength is called monochromatic light (chrome means colour). Sodium light is golden yellow in colour. So, sodium light is monochromatic light.

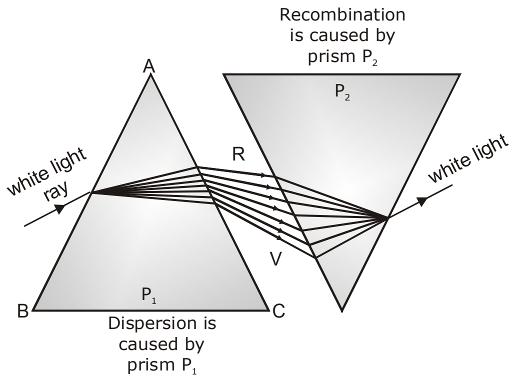
The light made up of many colours, or light consisting of radiations of many wavelengths, is called polychromatic light. White light is made up of seven colours. So, white light (or sunlight) is a polychromatic light.

How is the dispersed white light recomposed

Recombination of the seven colours of the dispersed white light to get white light is called recomposing of the dispersed white light.



Different colours bend though different angles during refraction through a glass prism. Other colours lie in between the two



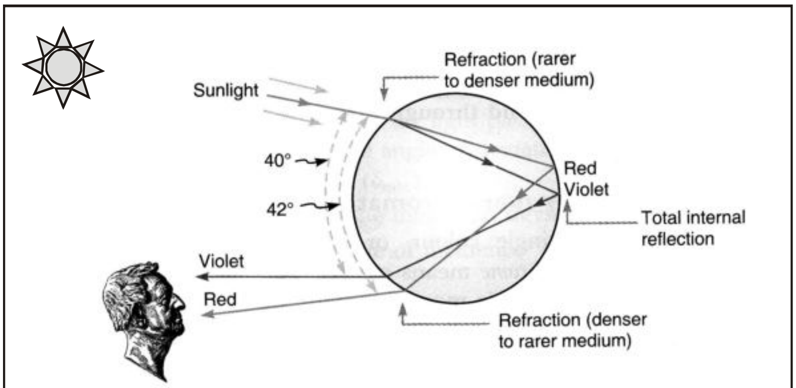
Recomposing the dispersed white light

How does a rainbow form

Rainbow is an example of the dispersion of white light.

Just after the rain, a large number of small droplets of water remain suspended in the air. Each drop acts like a small prism. When sunlight falls on these drops, the white light splits into seven colours. The dispersed light from a large number of drops forms a continuous band of seven colours. This coloured band is called rainbow. Thus, rainbow is produced due to dispersion of white light by small raindrops hanging in the air after the rain.

The rainbow is seen when the sun is behind the observer.



Refraction of sunlight by a spherical raindrop leading to the formation of the rainbow

SCATTERING OF LIGHT

When light falls on tiny particles then diffused reflection takes place and light spreads in all possible direction. This phenomenon is known as scattering of light.

Small particles scatter mainly blue light. When size of the particle increases then the light of longer wavelength also scatter. The path of a beam of light passing through a true solution is not visible. However, its path becomes visible through a colloidal solution where the size of the particles is relatively larger.

Rayleigh proved that the intensity of scattered light is inversely proportional to the fourth power of the wavelength, provided the scatters is smaller in size than the wavelength of light:

$$\text{scattering} \propto \frac{1}{\lambda^4}$$

(a) **Tyndall Effect:** The earth's atmosphere is a heterogeneous mixtures of minute particles. These particles include smoke, tiny water droplets, suspended particles of dust and molecules of air. When a beam of light strikes such fine particles, the path of the beam becomes visible.

The light reaches us after being reflected diffusely by these particles. The phenomenon of scattering of light by the colloidal particle gives rise to tyndall effect. This phenomenon is seen when a fine beam of sunlight enters a smoke filled room through a small hole. Thus, scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light.

(b) **Phenomena based upon Scattering of Light:** A number of optical phenomena can be explained on the basis of scattering of light:

(i) Colour of the clear sky is blue: When we look at the sky, we receive sunlight scattered by fine dust particles, air molecules and water-vapour molecules present in the atmosphere. Since blue light, which is present in larger proportion of the violet light in the sunlight, is scattered about ten times more than the orange-red light, the light reaching the eye is mainly blue. Hence the sky appears bluish.

If the earth had no atmosphere, there were no scattered sunlight and the sky would have appeared black. In fact, the sky does appear black to the astronauts in the space above the earth's atmosphere.

(ii) The clouds appears white: The dependence of scattering on $1/\lambda^4$ is valid only when the scatterer particles or molecules are much smaller than the wavelength of light, as are air molecules. Clouds, however, contain water droplets or ice crystals that are much larger than λ and they hence scatter light of all wavelengths nearly equally. Hence clouds appear white.

(iii) At sunrise or sunset the sun appears reddish: The scattering of light also explains the reddish appearance of sun at sunrise or sunset. At sunrise or sunset, the sun is near the horizon and the sunrays reach the earth after passing through a maximum distance in the atmosphere. During this passage, the light is scattered by air molecules and fine dust particles. Since scattering $\propto 1/\lambda^4$, most of the blue and neighbouring coloured light is scattered out before reaching the observer. Hence the light received by the observer is predominantly red. (For a similar reason, the sun appears orange-red in fog or mist.)

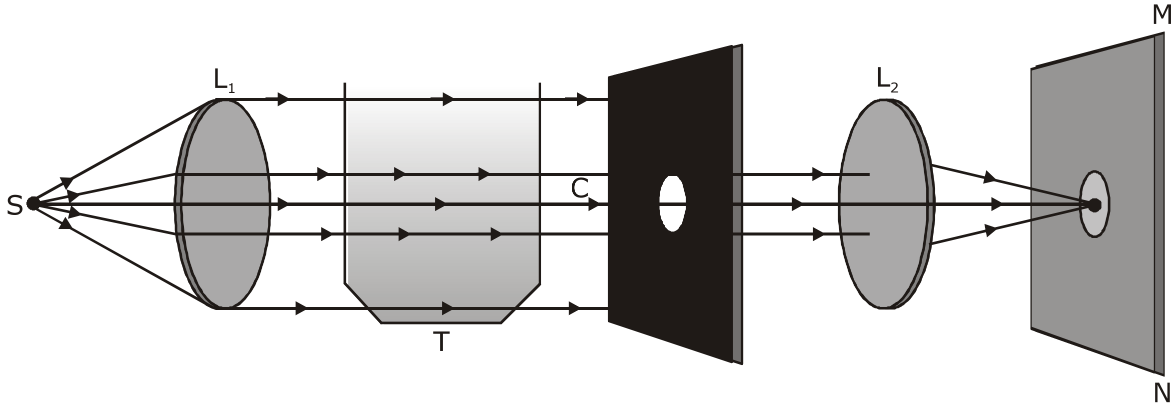
At noon, when the sun is overhead, the sunrays travel minimum distance in the atmosphere and there is little scattering. Hence the sun appears almost while (infact, slightly yellowish because some blue light is scattered).

(C) **Experimental verification of Scattering:** Let us do an activity to understand the colour of sun at sunrise and sunset. Place a strong source (s) of white light at the focus of converging lens (L_1). This lens provides a parallel beam of light to pass through a transparent glass tank (T) containing clear water. Allow the beam of light to pass through a circular hole (C) made in a cardboard. Obtain a sharp image of the circular hole on a screen (MN) using a second converging lens (L_2).

Dissolve 200g of sodium thiosulphate in 2L of clear water taken in the tank. Add 1 to 2 mL of concentrated sulphuric acid to the water. We observe that microscopic sulphur particles precipitate in 2 to 3 minutes. As sulphur particles begin to form we can observe the blue light from the three sides of the glass tank.

It is due to scattering of short wavelengths by minute colloidal sulphur particles. We observe that the colour of the transmitted light from the fourth side of glass tank facing the circular tank at first is orange red colour and then bright crimson red colour on the screen.

Light from the sun near the horizon passes through thicker layer of air and larger distance in the earth's atmosphere before reaching our eyes. Light from the sun travel relatively short distance. At moon, the sun appears white.



As a little of blue and violet colours are scattered. Near the horizon, most of the blue light and shorter wavelength are scattered away by the particles. Therefore, the light that reaches our eyes is of longer wavelength. This gives rise to the reddish appearance of the sun.

Newton's Thought

what is scattering?

It has been established that when an incident ray of light strikes a particle which has a diameter greater than the wavelength of incident light, then incident light is first absorbed by the particle and then transmitted in all possible directions. this is called scattering of light.

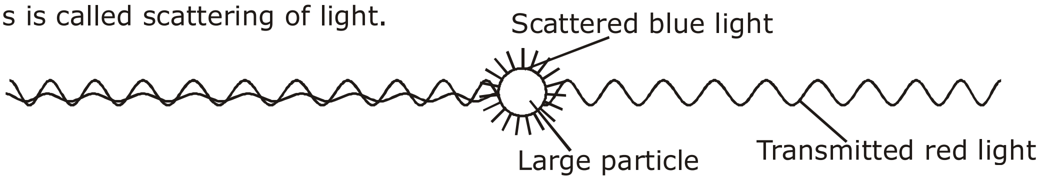
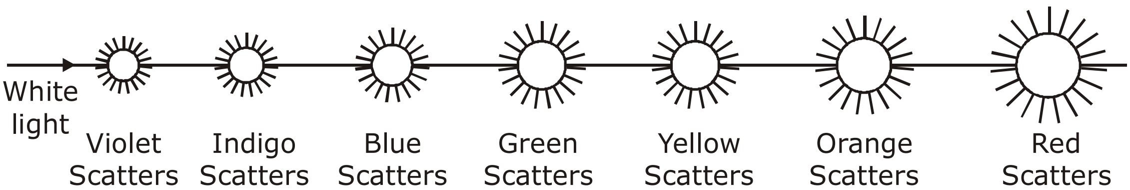


Figure shows a large particle whose diameter is greater than the wavelength of the blue light, but smaller than the wavelength of red light. Now, when a mixture of red and blue light is made incident on such a particle, then the blue light is absorbed by the particles and then transmitted in all possible directions, i.e., the blue light is scattered. The red light, however, continues moving straight as it is not absorbed or scattered.

Now, if your eyes receive tills scattered blue light, then to you the particle will appear blue in colour.

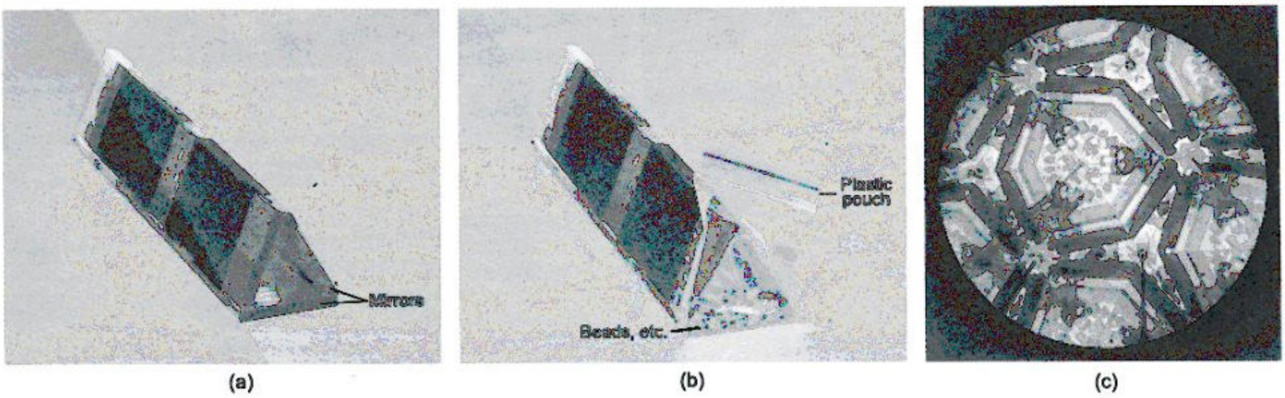
When the white sunlight enters the atmosphere of earth, the particle size is smallest. Thus, the violet light which has the smallest wavelength in white light scatters.



USE OF MULTIPLE REFLECTIONS

⇒ KALEIDOSCOPE

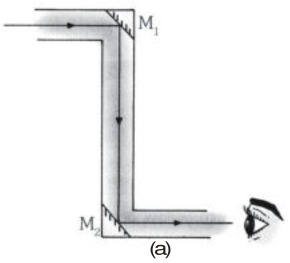
The keleidoscope is a device that uses reflections to produce patterns. It consists of mirrors inclined to each other. The mirrors form multiple images of objects in front of them. This creates beautiful patterns, which change when the keleidoscope is rotated or shaken.



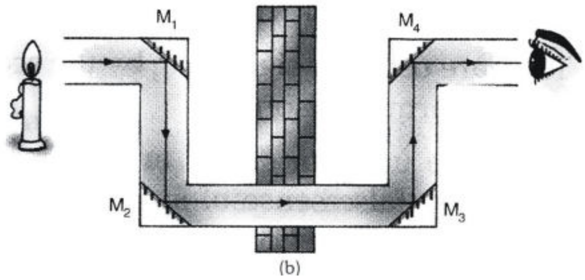
(a)-(b) Making a kaleidoscope (c) A pattern formed by a kaleidoscope

⇒ PERISCOPE

The working of a periscope is based on the principle of successive reflections from two plane mirrors. It consists of two plane mirrors M_1 and M_2 facing each other fixed at 45° to the framework of a tube which is bent twice at right angle (fig a). A beam of light from some object is turned through one right angle by the mirror M_1. In the same way the light is deviated through another right angle by the mirror M_2. Therefore, the object is seen by the eye in spite of the obstacle. This arrangement can be used by a person to see a match over the heads of a few people while standing at the back of the crowd.



Successive reflection from two plane mirrors in a periscope



Successive reflection through four plane mirrors in a periscope

Even an object can be seen through a wall as well by an arrangement as shown in fig.(b) In this case, light from the candle is reflected by four mirrors M_1, M_2, M_3 and M_4 before reaching the eye. Therefore, the candle is seen through the wall.

COLOURS OF THE OBJECT

(a) **Colour of objects in White and Coloured Light:** We known that white light is a mixture of seven colours. Light can be of different colours. Let us understand that why different objects appear to have different colours. A rose appear red because when white light falls on rose, it reflects only the red component and absorbs the other components.

We conclude that the colour of an object depends upon the colour of light it reflects.

Note:

(i) If an object absorbs lights of all colours and reflects none, it appears black.

(ii) If an object reflects light of all colour, it appears white when seen in white light.

(iii) When we talk of colour of an object, we refer to its colour as seen in white light.

(iv) A rose will appear black in green light because there is no red component in the light and it will not reflect any light. Hence no light will come from rose to the eye. Similarly if a green leaf is seen in red light, it appears black.

(v) If a white flower is seen in red light, it appear red because a white object reflects light of all colours falling on it. So it reflects the red light falling on it, which then enters the eye.

(b) **Primary Colours of Light:** Red, green and blue are primary colours of light and they produce white light when added in equal proportions. All colours can be obtained by mixing these three colours in different proportions.

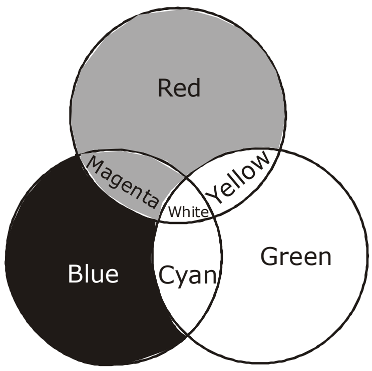
(c) **Secondary Colours or Composite Colours of Light:** The colours of light produced by adding any of primary colours are called secondary colours. Cyan, magenta and yellow are secondary colours of light.

Red + Green = Yellow

Green + Blue = Cyan

Red + Blue = Magenta

The method of producing different colours of light by adding the primary colours is called colour addition.



Additive Primaries

(d) **Complementary Colours of Light:** The lights of two colours which when added in equal proportions produce white light are called complementary colours of light and the two colours are called complements of each other.

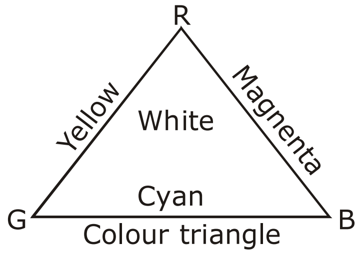
For example, yellow and blue light are complementary colours of light because when they mixed in equal proportions, they produce white light. We can also find the pairs of complimentary colours of light as follows.

Complimentary colours:

(Red + Green) + Blue = Yellow + Blue = White

Red + (Green + Blue) = Red + Cyan = White

(Red + Blue) + Green = Magenta + Green = White



Colour triangle

The above results can be diagrammatically represented in the form of a triangle as shown in figure. The outer limbs of the figure show the results of the addition of primary colours red, green and blue. The complementary colour pairs such as red and cyan are opposite to each other.

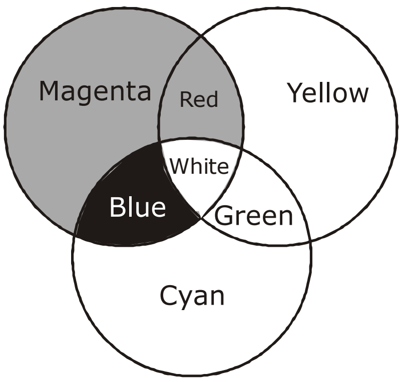
(e) Primary Colours of Pigment: Pigments are those substances that give colour to an object. The colour of a pigment as seen by us depends on what components of light it absorb or subtract from white light before reflecting that rest to our eyes. A primary colour (cyan, magenta, yellow) of a pigment is due to a primary colour of light being subtracted from white light.

White – Red – Blue + Green = Cyan

White – Green = Red + Blue = Magenta

White – Blue = Red + Green = Yellow

Mixing CMY (cyan, magenta, yellow) pigment in the correct proportions can produce millions of colour. If equal amount of pure



Subtractive Primaries

CMY pigments are mixed, we should get a black pigment.

However, printers use black ink in addition to CMY inks to get good results.

NCERT QUESTIONS WITH SOLUTIONS

Q.1 What is meant by power of accommodation of the eye?

Ans. The ability of the eye lens to adjust its focal length is called accommodation of the eye. Power of accommodation of an eye is defined as the maximum variation in the power or focal length of the eye lens.

Q.2 A person with a myopic eye cannot see objects beyond 1.2m distinctly. What should be the type of the corrective lens used to restore proper vision?

Ans. Concave lens of focal length given by

$$\frac{1}{f} = \frac{1}{d} = -\frac{1}{1.2m} \qquad \text{or} \qquad f = -1.2m \qquad \text{or} \qquad P = \frac{1}{f} = \frac{1}{1.2} = 0.83D$$

Q.3 What is the far point and near point of the human eye with normal vision?

Ans. The farthest position of an object from the human eye so that its sharp image is formed on the retina is at infinite distance from the eye.

The nearest position of an object from a human eye so that its sharp image is formed on the retina is at 25cm from the eye.

Q.4 A student has difficulty in reading the black board while sitting in the last row. What could be the defect the child is suffering from? How can it be corrected?

Ans. Near sighted or myopia. This defect can be corrected by using lens of suitable focal length.

Q.5 A person needs a lens of power –5.5 diopter for correcting distant vision. For correcting his near vision, he needs a lens of power +1.5 diopter. What is the focal length of the lens required for correcting (i) distant vision and (ii) near vision?

Ans. (i) $\frac{1}{f} = \frac{1}{P} = -\frac{1}{5.5} = -0.18m = -18.0cm$

(ii) $\frac{1}{f} = \frac{1}{P} = \frac{1}{1.5} = 0.67m = -67.0cm$

Q.6 The far point of a myopic person is 150cm in front the eye. What is the nature and power of the lens required to correct the problem?

Ans. $\frac{1}{f} = -\frac{1}{d} = \frac{1}{150cm}$ or $f = -150cm$

$\therefore$ Power $= \frac{100}{f} = -\frac{100}{150} = 0.67D$

The lens is concave lens.

Q.7 Make a diagram to show how hypermetropia is corrected. The near point of a hypermetropic eye is 1m. What is the power of the lens required to correct this defect? Assume that the near point of the normal eye is 25cm.

Ans. For diagram, refer figure 4.

$$\frac{1}{f}=\frac{1}{25cm}+\frac{1}{(d)}=\frac{1}{25}-\frac{1}{100}=\frac{3}{100} \qquad \text{or} \qquad f=\frac{100}{3}cm$$

$$\therefore \text{ Power } = \frac{100}{f} = +3.0D$$

Q.8 Why is a normal eye not able to see clearly the objects placed closer than 25 cm?

Ans. The nearest position of an object from normal human eye so that its sharp image of the object is formed on retina is 25cm. If the object is placed at a distance less than 25cm, then the blurred image of the object is formed on retina as the focal length of eye lens cannot by decreased below a certain limit. Hence, eye cannot see it clearly.

Q.9 What happens to the image distance in the eye when we increase the distance of an object from the eye?

Ans. The image distance remains the same in the eye because the eye has the ability to change the focal length of its lens to make the image always on the retina when the object distance increase from the eye?

Q.10 Why do stars twinkle?

Ans. Refer Theory

Q.11 Explain why the planets do not twinkle?

Ans. Refer Theory

Q.12 Why does the sun appear red early in the morning?

Ans. Refer Theory

Q.13 Why does the sky appear dark instead of blue to an astronaut?

Ans. The blue colour of sky is de to the scattering of sunlight. The scattering of sunlight in the atmosphere is due to the presence of atoms and molecules of gas, dropets and dust particles. When the astronaut is in space, then there is no atmosphere (or atoms and molecules of gases, droplets and dust particles) around him. Therefore sunlight does not scatter and hence sky appears dark.

Q.14 A young boy can adjust the power of his eye-lens between 50D & 60D. His far point is infinity.

(a) What is the distance of his retina from the eye-lens?

(b) What is his near point?

Ans. (a) When the eye is fully relaxed, its focal length is largest and the power of the eye, lens is minimum. This power is 50D according to the given data. The focal length is 1/50m = 2cm. As the far point is at infinity, the parallel rays coming from infinity are focused on the retina in the fully relaxed condition. Hence, the distance of the retina from the lens equals the focal length which is 2cm.

(b) When the eye is focused at the near point, the power is maximum which is 60D. The focal length in this case is f = 60m = 5/3cm. The image is formed on the retina and thus v = 2cm. We have,

$$\frac{1}{v}=\frac{1}{u}=\frac{1}{f}, \quad \text{or} \quad \frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{1}{2}-\frac{3}{5} \quad \text{or} \quad u = -10\text{cm}$$

Q.15 What is the difference between images produced by a telescope and binoculars?

Ans. The image produced by telescope does not give perception of depth whereas the image produced by binoculars produces 3-dimensional image with increased field of view and intensity.

Q.16 A person cannot see objects clearly beyond 50cm. Find the power of the lens to correct the vision.

Ans. Here v = −50 mm, u = ∞. Hence using $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$.

We find f = −50cm = 0.5m.

So power of the lens is $P = \frac{1}{-0.50\text{m}} = -2\text{D}$

Q.17 A myopic persons having far point 80cm uses spectacles of power −1.0D. How far can he see clearly?

Ans. Use $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$. Hence v = −80cm; f = +100cm

Hence $\frac{1}{-80}-\frac{1}{u}=\frac{1}{100}$

or $-\frac{1}{u}=\frac{1}{100}+\frac{1}{80}=\frac{-80+100}{80\times100}$. This gives u = −400cm = −4cm

EXERCISE – I BOARD PROBLEMS

Q.1 What is meant by persistence of vision ? **(2003)**

Q.2 What kind of lens is used in the spectacles of a person suffering from myopia (near sightedness)? **(2006)**

Q.3 List three common defects of vision that can be corrected with the use of spectacles. **(2006)**

Q.4 Write the function of Iris in the human eye. **(2007)**

Q.5 To an astronaut, why does the sky appear dark instead of blue? **(2008)**

Q.6 Why does the sun appear reddish at sunrise? **(2008)**

Q.7 Why is red colour selected for danger signal lights? **(2008)**

Q.8 The far point of a myopic person is 80 cm in front of the eyes. What is the nature and power of the lens required to enable him to see very distant objects distinctly? **(2003)**

Q.9 Explain about the colour of the sun at sunrise and sunset. **(2007)**

Q.10 What are the conditions for formation of rainbow? **(2003)**

Q.11 Draw a labelled diagram of human eye.

What is power of accommodation of eye? Define colour blindness. **(2005)**

Q.12 (a) Draw a diagram to show the formation of image of a distant object by a myopic eye. How can such an eye defect be remedied ?

(b) State two reasons due to which this eye defect may be caused.

(c) A person with myopic eye cannot see objects beyond a distance of 1.5 m. What would be the power of the corrective lens used to restore proper vision ? **(2008)**

Q.13 What is long sightedness ? List two causes for development of long-sightedness. Describe with a ray diagram, how this defect may be corrected by using spectacles. **(2005)**

Q.14 (a) State two main causes of a person developing near sightedness. With the help of a ray diagram, suggest how he can be helped to overcome this disability ?

(b) The far point of a myopic person is 150 cm in front of the eye. Calculate the focal length and power of a lens required to enable him to see distant objects clearly. **(2004)**

Q.15 (a) Explain the following terms used in relation to defects of vision and corrections provided for them: (i) Myopia (ii) Astigmatism (iii) Presbyopia (iv) Far sightedness.

(b) Describe with a ray diagram how a person with myopia can be helped by spectacles. **(2005)**

Q.16 A 14 year old student is not able to see clearly the questions written on blackboard placed at a distance of 5 m from him. (a) Name the defect of vision he is suffering from. (b) With the help of labelled ray diagrams, show how this defect can be corrected. (c) Name the type of lens used to correct the defect. **(2007)**

Q.17 (a) What is meant by dispersion of white light? Describe the formation of rainbow in the sky with the help of a diagram.

(b) What is hypermetropia? Draw ray diagrams to show the image formation of an object by (i) hypermetropic eye (ii) correction made with a suitable lens for hypermetropic eye. **(2008)**

Q.18 (a) Give reasons for the following:

(i) Colour of the clear sky is blue.

(ii) The sun can be seen about two minutes before actual sunrise.

(iii) We cannot see an object clearly if it is placed very close to the eyes.

(b) What is presbyopia? Write two causes of this defect.

EXERCISE – II | NTSE /OLYMPIAD /FOUNDATION PROBLEMS

Q.1 A parallel beam of light falling on the eye gets focused on the retina because of refractions at:

(A) the cornea

(B) the crystalline lens

(C) the vitreous humor

(D) various surfaces in the eye

Q.2 The combination responsible for admitting different amounts of light into the eye is:

(A) ciliary muscles and crystalline lens

(B) ciliary muscles and pupil

(C) iris and pupil

(D) rods and cones

Q.3 The muscles of the iris control the:

(A) focal length of the eye-lens

(B) opening of the pupil

(C) shape of the crystalline lens

(D) optic nerve

Q.4 When the eye is focused on an object very far away, the focal length of the eye-lens is:

(A) maximum

(B) minimum

(C) equal to that of the crystalline lens

(D) half its maximum focal length

Q.5 Other names for myopia are:

(A) hyperopia and hypermetropia

(B) long-sightedness and hyperopia

(C) near-sightedness and presbyopia

(D) near-sightedness and short-sightedness

Q.6 The inability among the elderly to see nearby objects clearly because of the weakening of: the ciliary muscles is called:

(A) far-sightedness

(B) near-sightedness

(C) presbyopia

(D) astigmatism

Q.7 When white light passes through a prism, it splits into its component colours. This phenomenon is called:

(A) spectrum (B) reflection

(C) refraction (D) dispersion

Q.8 The number of surfaces bounding a prism is:

(A) 3 (B) 4

(C) 5 (D) 6

Q.9 The wavelengths corresponding to violet, yellow and red lights are λ_v , λ_y and λ_r respectively.

(A) $\lambda_v > \lambda_y > \lambda_r$ (B) $\lambda_v < \lambda_y < \lambda_r$

(C) $\lambda_y < \lambda_v < \lambda_r$ (D) $\lambda_y < \lambda_r < \lambda_v$

Q.10 The focal length of eye lens is controlled by:

(A) Iris (B) Cornea

(C) Ciliary muscles (D) Optic nerve

Q.11 A white light falls on a glass prism, the least deviated colour is-

(A) Violet (B) Orange

(C) Red (D) Yellow

Q.12 Blue colour of sky is due to-

(A) dispersion of light

(B) scattering of light

(C) refraction of light

(D) reflection of light

Q.13 Rainbow is formed due to-

(A) reflection and dispersion of light through the water droplets

(B) total internal reflection, refraction and dispersion of light through the water droplets

(C) only dispersion of light

(D) only refraction of light

Q.14 Power of accommodation (max. variation in power of eye lens) of a normal eye is about:

(A) 1D (B) 2D

(C) 3D (D) 4D

Q.15 Dispersion of light by a prism is due to the change in-

(A) frequency of light

(B) speed of light

(C) scattering

(D) none of these

Q.16 Least distance of distinct vision of a long-sighted man is 40 cm. He wish to reduce it to 25 cm by using a lens the focal length of the lens is-

(A) $+\frac{200}{3}$ cm (B) $-\frac{200}{3}$ cm

(C) +200 cm (D) -200 cm

Q.17 Which of the following colour has the least wavelength?

(A) Red (B) Orange

(C) Violet (D) Blue

Q.18 Convex lens of suitable focal length can correct-

(A) short sightedness

(B) long sightedness

(C) presbyopia

(D) astigmatism

Q.19 The focal length of human eye lens is (with relaxed eye)-

(A) 2.5 cm (B) 25 cm

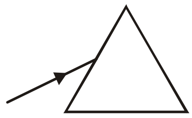
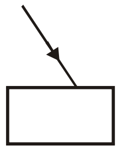
(C) 25 m (D) 2.5 m

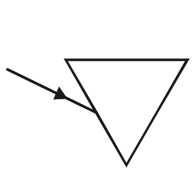
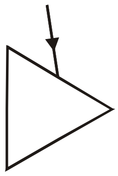
Q.20 The middle colour in sunlight spectrum is: **[NTSE]**

(A) yellow (B) green

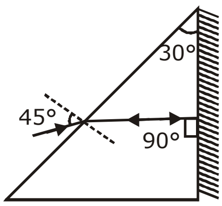
(C) blue (D) orange

Q.21 In which of the following cases will there be no dispersion when sunlight passes: **[NTSE]**

(A)  (B) 

(C)  (D) 

Q.22 A ray of light falls on a prism having one silvered surface, at an incident angle of 45° as shown in figure. After refraction and reflection it retraces the path, then the refractive index of prism materials is (prism angle is 30°):



(A) $\sqrt{2}$ (B) 2 **[NTSE]**

(C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{2}$

Q.23 A rainbow has circular shape because: **[NTSE]**

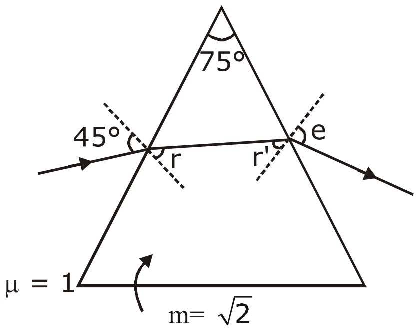
(A) the earth is spherical

(B) rain drops are spherical

(C) the sun is spherical

(D) none of these

Q.24 Find the value of $\angle$r' for the case shown in figure: **[NTSE]**



(A) $\sin^{-1}(0.5)$ (B) $75° - \sin^{-1}(0.5)$

(C) 90° (D) 60°

Q.25 Dispersion of white light into its constituent colours occurs during: **[NTSE]**

(A) reflection at a plane mirror

(B) reflection at a concave mirror

(C) internal reflection inside a spherical drop of water

(D) refraction at the boundary of a transparent medium

Q.26 A ray of light passing through an equilateral triangular prism gets deviated at least by 30°. Then, the refractive index of the material of the prism must be: **[NTSE]**

(A) $\leq \sqrt{2}$ (B) $\geq \sqrt{2}$

(C) $\leq \sqrt{3}$ (D) $\geq \sqrt{3}$

Q.27 Our eye makes use of the property of: **[NTSE]**

(A) convex lens (B) concave lens

(C) cylindrical lens (D) none of these

Q.28 Most of the refraction of light takes place in the: **[NTSE]**

(A) iris (B) cornea

(C) pupil (D) retina

Q.29 The central circular aperture of ______ is called _________. **[NTSE]**

(A) iris, pupil (B) pupil, iris

(C) retina, iris (D) none of these

Q.30 When the light is very bright: **[NTSE]**

(A) the iris makes the pupil expand

(B) the iris makes the pupil contract

(C) the iris and the pupil remain as they are

(D) none of these

Q.31 Who discovered by his experiments with glass prisms that white light consists of seven colours? **[NTSE]**

(A) Newton (B) Faraday

(C) Maxwell (D) Young

Q.32 The light which refracts most while passing through a prism is: **[NTSE]**

(A) red (B) violet

(C) indigo (D) yellow

Q.33 Which of the following colours of light undergoes the least deviation while passing through a glass prism? **[NTSE]**

(A) red (B) blue

(C) yellow (D) green

Q.34 Which of the following colour of light undergoes the maximum deviation while passing through a glass prism? **[NTSE]**

(A) red (B) blue

(C) violet (D) green

Q.35 Which of the following sources of light is different from others? **[NTSE]**

(A) sunlight

(B) white light

(C) light from a bulb

(D) sodium light

Q.36 The wavelength of light is expressed in: **[NTSE]**

(A) metre (B) micron

(C) light year (D) angstrom

Q.37 A magnifying glass comprises a simple: **[NTSE]**

(A) convex lens (B) convex mirror

(C) concave lens (D) concave mirror

Q.38 The least distance of distinct vision for a normal person is: **[NTSE]**

(A) 1 m (B) 25 cm

(C) 25 m (D) none of these

Q.39 The power of a lens having a focal length of 1 cm is: **[NTSE]**

(A) 1 D (B) 10 D

(C) $\frac{1}{10}$D (D) 100 D

Q.40 A camera is an optical instrument which makes use of a: **[NTSE]**

(A) convex lens (B) concave lens

(C) cylindrical lens (D) none of these

Q.41 The inability of a lens to bring all the rays coming from a point object to focus at one single point is called: **[NTSE]**

(A) spherical aberration

(B) parallex

(C) optical illusion

(D) none of these

Q.42 The spherical aberration can be minimised by: **[NTSE]**

(A) reducing the aperture of the lens

(B) using specially made meniscus lens

(C) combination of lenses made of different glasses

(D) none of these

ANSWER KEY

1.	D	**2.**	C	**3.**	B	**4.**	A
5.	D	**6.**	C	**7.**	D	**8.**	C
9.	B	**10.**	C	**11.**	C	**12.**	B
13.	B	**14.**	D	**15.**	B	**16.**	A
17.	C	**18.**	B	**19.**	A	**20.**	B
21.	B	**22.**	A	**23.**	B	**24.**	B
25.	D	**26.**	B	**27.**	A	**28.**	B
29.	A	**30.**	B	**31.**	A	**32.**	B
33.	A	**34.**	C	**35.**	D	**36.**	D
37.	A	**38.**	B	**39.**	D	**40.**	A
41.	A	**42.**	D				

EXERCISE – III — ISO/NSTES QUESTIONS

1. When does the total internal reflection take place :-
(A) Refraction from air into any denser medium
(B) Refraction of ray incident from rarer medium
(C) Ray incident from denser medium, with angle of refraction 90°
(D) Ray incident from denser medium with refractive index is [n > 1/(sin of angle of incidence)]

2. When the ray of light is incident from denser medium having refractive index 2, what should be the angle of incidence for the ray to go out :-
(A) Less than 30° (B) Less than 45° (C) Less than 60° (D) Less than 90°

3. A monochromatic beam of light passes from a denser medium into a rarer medium as a result :-
(A) Its velocity increase (B) Its velocity decrease
(C) Its frequency decrease (D) Its wavelength decreases

4. Immiscible transparent liquids A, B, C, D and E are placed in a rectangular container of glass with the liquids making laxers according to their densities. The refractive index of the liquids are shown in the adjoining diagram. The container is alluminated from the side and a small piece of glass having refractive index 1·61 is gently dropped into the liquid laxo. The glass piece as descends downwards will not be vissible in :-

$\mu = 1{\cdot}64$	A
$\mu = 1{\cdot}63$	B
$\mu = 1{\cdot}61$	C
$\mu = 1{\cdot}64$	D
$\mu = 1{\cdot}6$	E

(A) Liquid A and B only
(B) Liquid C only
(C) Liquid D and E only
(D) Liquid A, B, D and E

5. Sensitivity of eye is maximum for :-
(A) 4000 Å (B) 8000 Å (C) 5550 Å (D) 6000 Å

6. A bird in air looks at a fish vertically below it and inside water. x is the height of the bird above the surface of water and y is the depth of the fish below the surface of water. The distance of the fish as observed by the bird is : (Given μ = refractive index of water w.r.t. air) :-
(A) $x + y$ (B) $x + \frac{y}{\mu}$ (C) $\mu x+y$ (D) $\mu x+\mu y$

7. In the previous question, the distance of the bird as observed by the fish is :-
(A) $x + y$ (B) $x + \frac{y}{\mu}$ (C) $\mu x + y$ (D) $\mu x+\mu y$

8. An object is placed between two parallel plane mirror. The number of images formed is
(A) four (B) one (C) two (D) infinite

9. An object is placed between two plane mirrors inclined at some angle to each other. If the number of images formed is 7 then the angle of inclination is
(A) 15° (B) 30° (C) 45° (D) 60°

10. Which of the following letters do not surface lateral inversion.
(A) HGA (B) HOX (C) VET (D) YUL

11. A clock hung on a wall has marks instead of numbers on its dial. On the opposite wall there is a mirror, and the image of the clock in the mirror if read, indicates the time as 8.20. What is the time in the clock-
(A) 3.40 (B) 4.40 (C) 5.20 (D) 4.20

12. If you want to see your full image, then minimum size of the mirror
(A) Should be of your height (B) Should be half of your height
(C) Should be twice of your height (D) Depends upon distance from the mirror

13. If an object is placed unsymmetrically between two plane mirrors, inclined at an angle of 72°, then the

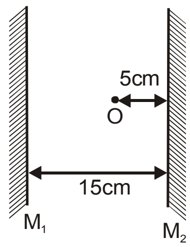
total number of images formed is-

(A) 5 (B) 4 (C) 2 (D) Infinite

14. At what angle must two plane mirrors be placed so that incident and resulting reflected rays are always parallel to each other

(A) 0° (B) 30° (C) 60° (D) 90°

15. Figure shows two plane mirrors parallel to each other and an object O placed between them. Then the distance of the first three images from the mirror M_2 will be :(in cm)



(A) 5, 10, 15 (B) 5, 15, 30 (C) 5, 25, 35 (D) 5, 15, 25

16. If an object is placed 10 cm in front of a concave mirror of focal length 20 cm, the image will be :–

(A) diminished, upright, virtual (B) enlarged, upright, virtual

(C) diminished, inverted, real (D) enlarged, upright, real

17. The magnification m, the image position v and focal length f are related to one another by the relation -

(A) $m = \frac{f-v}{f}$ (B) $m = \frac{f}{f-v}$ (C) $m = \frac{f+v}{f}$ (D) $m = -\frac{f}{f-v}$

18. The relation between magnification m, the object position u and focal length f of the mirror is

(A) $m = \frac{f-u}{f}$ (B) $m = \frac{f}{f-u}$ (C) $m = \frac{f+u}{f}$ (D) $m = \frac{f}{f+u}$

19. v_1 is velocity of light in first medium, v_2 is velocity of light in second medium, then refractive index of second medium with respect to first medium is

(A) v_1/v_2 (B) v_2/v_1 (C) $\sqrt{v_1 / v_2}$ (D) $\sqrt{v_2 / v_1}$

20. The ratio of the refractive index of red light to blue light in air is

(A) Less than unity

(B) Equal to unity

(C) Greater than unity

(D) Less as well as gratert than unity depending upon the experimental arrangement

21. The refractive index of glass and water with respect to air are 3/2 and 4/3 respectively. The refractive index of glass with respect to water is

(A) 8/9 (B) 9/8 (C) 2 (D) 1/2

22. If ${}_i\mu_j$ represents refractive index when a light ray goes from medium i to medium j, then the product ${}_2\mu_1 \times {}_3\mu_2 \times {}_4\mu_3$ is equal to

(A) ${}_3\mu_1$ (B) ${}_3\mu_2$ (C) $\frac{1}{{}_1\mu_4}$ (D) ${}_4\mu_2$

23. What is the basic reason for the shining of a diamond ?

(A) Reflection (B) Refraction (C) Dispersion of light (D) Total internal reflection

24. Total internal reflection of a ray of light is possible when the (i_c = critical angle, i = angle of incidence)

(A) Ray goes from denser medium to rarer medium and $i < i_c$

(B) Ray goes from denser medium to rarer medium and $i > i_c$

(C) Ray goes from rarer medium to denser medium and $i > i_c$

(D) Ray goes from rarer medium to denser medium and $i < i_c$

25. A convex lens of focal length A and a concave lens of focal length B are placed in contact. The focal length of the combination is

(A) A + B (B) (A - B) (C) $\frac{AB}{(A+B)}$ (D) $\frac{AB}{(B-A)}$

26. Near and far points of a human eye are

(A) zero and 25 cm (B) 25 cm and 50 cm (C) 50 cm and 100 cm (D) 25 cm and infinite

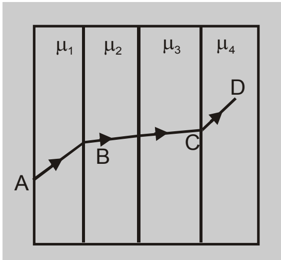
27. The focal length of a concave mirror is f and the distance from the object to the principal focus is x. Then the ratio of the size of the image to the size of the object is-

(A) $\frac{(f+x)}{f}$ (B) $\frac{f}{x}$ (C) $\sqrt{\frac{f}{x}}$ (D) $\frac{f^2}{x^2}$

28. Light travels through a glass plate of thickness t and having refractive index n. If c is the velocity of light in vacuum. the time taken by the light to travel this thickness of glass is :–

(A) $\frac{t}{nc}$ (B) tnc (C) $\frac{nt}{c}$ (D) $\frac{tc}{n}$

29. A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3, and μ_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have:



(A) $\mu_1 = \mu_2$ (B) $\mu_2 = \mu_3$ (C) $\mu_3 = \mu_4$ (D) $\mu_4 = \mu_1$

30. Which of the following is used in optical fibres?

(A) Total internal reflection (B) Scattering

(C) Diffraction (D) Refraction

31. Electromagnetic radiation of frequency n, wavelength λ, travelling with velocity v in air, enters a glass slab of refractive index μ. The frequency, wavelength and velocity of light in the glass slab will be respectively :–

(A) $\frac{n}{\mu}, \frac{\lambda}{\mu}, \frac{v}{\mu}$ (B) n , $\frac{\lambda}{\mu}, \frac{v}{\mu}$ (C) n, λ, $\frac{v}{\mu}$ (D) $\frac{n}{\mu}, \frac{\lambda}{\mu}$v

32. A plane glass slab is kept over various coloured letters; the letter which appears least raised is

(A) blue (B) voilet (C) green (D) red

33. A convex lens of focal length f will form a magnified real image of an object if the object is placed

(A) anywhere beyond 2f (B) anywhere beyond f (C) between f and 2f

(D) between lens and f

34. A convex lens is making full image of an object. if half of lens is covered by an opaque object, then

(A) half image is not seen (B) full image of same intensity is seen

(C) full image of decreased intensity is seen (D) half image of same intensity is seen

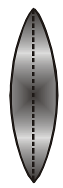
35. When a thin convex lens is put in contact with a thin concave lens of the same focal length, the resultant combination has a focal length equal to

(A) f/2 (B) 2f (C) 0 (D) ∞

36. Focal length of a convex lens will be maximum for

(A) blue light (B) yellow light (C) green light (D) red light

37. A convex lens has a focal length f. It is cut into two parts along the dotted line as shown in the figure. The focal length of each part will be



(A) $\frac{f}{2}$

(B) f

(C) $\frac{3}{2}f$

(D) 2f

38. A convex lens is made up of three different materials as shown in the figure. For a point object placed on its axis, the number of images formed are

(A) 1

(B) 3

(C) 4

(D) 5

39. Myopia is the defect of vision due to which a person finds difficulty in seeing

(A) distant objects (B) near objects (C) objects at all distances (D) colours

40. Loss of the ability of eye to focus on near and far objects with advancing age is called

(A) Presbyopia (B) Astigmatism (C) Hypermetropia (D) Myopia

41. Astigmatism can be corrected by

(A) Bifocal lenses (B) Cylindrical lenses (C) Concave lenses (D) Planoconvex lenses

42. A normal eye is not able to see objects closer than 25 because

(A) The focal length of the eye is 25 cm

(B) The distance of the retina form the eye lens is 25 cm

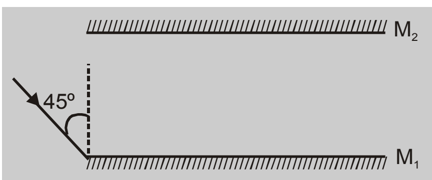
(C) The eye is not able to decrease the distance between the eye lens and the retina beyond a limit

(D) The eye is not able to decrease the focal length beyond a limit

43. Myopia can be removed by using a lenses of

(A) concave lens (B) convex lens (C) cylindrical lens (D) by surgical removal

44. Two plane mirrors M_1 and M_2 each have length 1m and are separated by 1cm. A ray of light is incident on one end of mirror M_1 at angle 45º. How many reflections the ray will have before going at from the other end



(A) 50 (B) 51 (C) 100 (D) 101

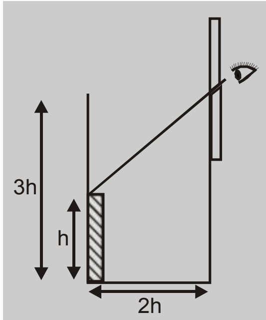
45. 'Mirage' is a phenomenon due to :–

(A) relfection of light (B) reflraction of light

(C) total internal reflection of light (D) diffraction of light

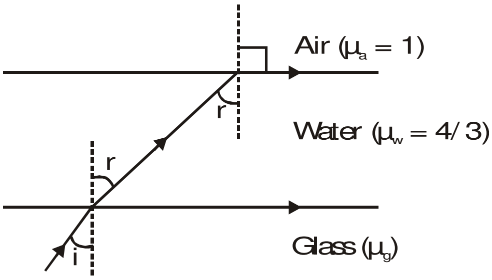
46. An observer can see through a pin-hole the top end of a thin rod of height h, placed as shown in the

figure. The beaker height is 3h and its radius h. When the beaker is filled with a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is–



(A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$ (C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$

47. A ray of light is incident at the glass-water interface at an angle i. It emerges finally parallel to the surface of water as shown in fig. The value of μ_g would be –



(A) $\left(\frac{4}{3}\right)\sin i$ (B) $\frac{1}{\sin i}$ (C) $\frac{2}{\sqrt{3}\sin i}$ (D) 1.5

48. When a ray of light enters a glass slab from air –

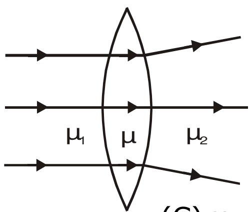
(A) Its wavelength decreases. (B) Its wavelength Increases.

(C) Its frequence Increases. (D) Neither wavelength nor frequence changes.

49. The distance between the object and the real image formed by a convex lens is d. if the magnification is m, the focal length of the lens is –

(A) $\frac{md}{(m+1)^2}$ (B) $\frac{md}{(m+1)}$ (C) $\frac{md}{(m-1)^2}$ (D) $\frac{md}{m-1}$

50. A parallel beam of light falls on a convex lens. The path of the rays is shown in fig. It follows that –



(A) $\mu_1 > \mu > \mu_2$ (B) $\mu_1 < \mu < \mu_2$ (C) $\mu_1 = \mu < \mu_2$ (D) $\mu_1 = \mu > \mu_2$

51. A person is looking at the image of his face in a mirror by holding it close to his face. The image is virtual. When he moves the mirror away from his face, the image is inverted. What type of mirror is he using?

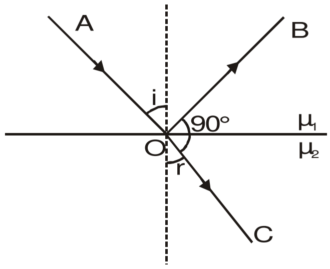
(A) Plane mirror (B) Convex mirror (C) Concave mirror (D) None of these

52. Two objects A and B when placed in turn in front of a concave mirror of focal length 7.5 cm, give images of equal size. If A is three times the size of B and is placed 30 cm from the mirror, what is the distance of B from the mirror –

(A) 10 cm (B) 12.5 cm (C) 15 cm (D) 17.5 cm

53. A ray of light in medium of refractive index μ_1 is partly reflected and refracted at the boundary of

a medium of refractive index μ_2 as shown fig. If $\angle BOC = 90°$. The value of angle i is given by –



(A) $\tan^{-1}(\mu_1/\mu_2)$ (B) $\tan^{-1}(\mu_2/\mu_1)$ (C) $\sin^{-1}(\mu_2/\mu_1)$ (D) $\cos^{-1}(\mu_1/\mu_2)$

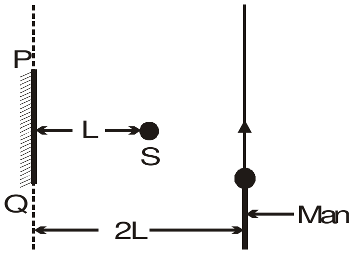
54. Two transparent media A and B separated by a plane boundary. The speed of light in medium A is 2.0×10^8 ms^{-1} and in medium B 2.5×10^8 m s^{-1}. The critical angle for which a ray of light going from A to B it totally internally reflected is –

(A) $\sin^{-1}\left(\frac{1}{2}\right)$ (B) $\sin^{-1}\left(\frac{2}{5}\right)$ (C) $\sin^{-1}\left(\frac{4}{5}\right)$ (D) None of these

55. An air bubble in a glass slab ($\mu = 1.5$) is 6 cm deep when viewed through one face and 4 cm deep when viewed through the opposite face. What is the thickness of the slab?

(A) 7.0 cm B) 7.5 cm (C) 15 cm (D) 10.5 cm

56. A point source of light S is placed at a distance L in front of the centre of a plane mirror PQ of width d hung vertically on a wall as shown in fig. A man walks in front of the mirror along a line parallel to the mirror at a distance 2L from it as shown. The greatest distance over which he can see the image of the light source in the mirror is –

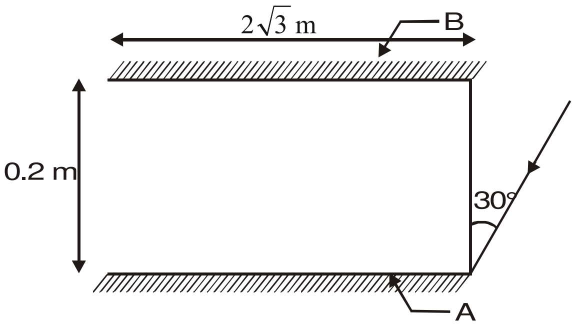


(A) $\frac{d}{2}$ (B) d (C) 2d (D) 3d

57. Two plane mirros, each 1.6 m long, are held parallel and facing each other at a separation of $20\sqrt{3}$ cm. A ray of light is incident at the end of one mirror at an angle of incidence of 30°. The total number of reflections the ray suffers before emerging from the system of mirrors is –

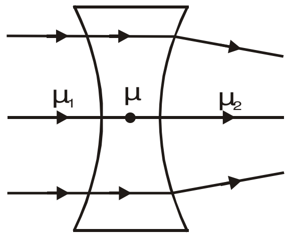
(A) 10 (B) 12 (C) 14 (D) 16

58. Two plane mirrors A and B are aligned parallel to each other, as shown in Fig. A light ray is incident at an angle of 30° at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is –



(A) 28 (B) 30 (C) 32 (D) 34

59. What is the relation between refractive indices μ, μ_1 and μ_2 if the behaviour of light rays is as shown in fig.



(A) $\mu > \mu_2 > \mu_1$ (B) $\mu < \mu_2 < \mu_1$ (C) $\mu < \mu_2 : \mu = \mu_1$ (D) $\mu_2 < \mu_1 : \mu = \mu_2$

60. A lens of power +2.0D is placed in contact with another lens of power –1.0D, the combination will behave like :-

(A) A converging lens of focal length 100 cm

(B) A diverging lens of focal length 100 cm

(C) A converging lens of focal length 50 cm

(D) A diverging lens of focal length 50 cm

61. Which of the following statements is/are correct?

(A) The laws of reflection of light hold for plane as well as curved reflecting surfaces.

(B) The size of a virtual image can be measured by receiving it on a screen.

(C) A dentist uses a convex mirror to examine a small cavity.

(D) The focal length of a spherical mirror is half the radius of curvature for all rays.

62. Choose the correct statement(s) from the following:

(A) To a fish under water looking obliquely at a man standing on the bank of lake, the man looks taller than his actual height.

(B) The apparent depth of a tank of water is more for oblique viewing than for normal viewing.

(C) The focal length of a concave mirror will not change if it is immersed in water.

(D) In no situation will a converging lens behave like a diverging lens.

63. An air bubble under water shines brightly because of the phenomenon of –

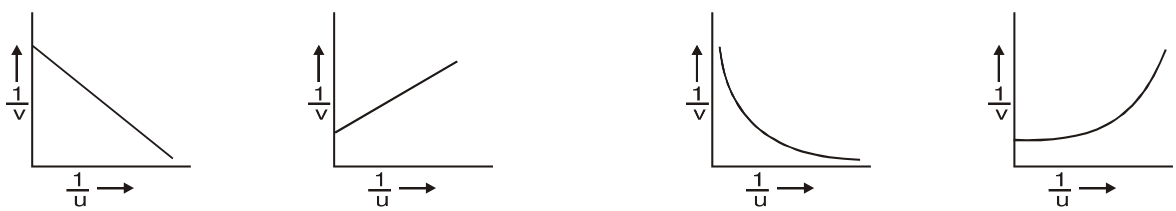
(A) Dispersion (B) Interference

(C) Diffraction (D) Total internal reflection

64. The distance v of the real image formed by a convex lens is measured for various object distances u.
A graph is plotted between v and u. Which one of the graphs shown in fig. is approximately correct?

(A) (B) (C) (D)

65. If a graph is plotted between 1/v and 1/u, which one of the graphs shown in fig. approximately correct?



(A) (B) (C) (D)

66. Which one of the following statements is correct for spherical mirrors ?

(A) A concave mirror forms only virtual images for any position of the object.

(B) A convex mirror forms only virtual images for any position of the object.

(C) A concave mirror forms only a virtual diminished image of an object placed between its pole and the focus.

(D) A convex mirror forms a virtual magnified image of an object placed between its pole and the focus.

67. A concave mirror produces a real image twice the size of the object when place at a distance of 22.5 cm from it. At what distance from the mirror should the object be placed so that the image becomes three times the size of the object?

(A) 20 cm

(B) 25 cm

(C) 30 cm

(D) 40 cm

68. The distance of an object from the focus of a concave mirror of focal length f is x and the distance of the real image from the focus is y. Then

(A) $\frac{1}{x}+\frac{1}{y}=\frac{1}{f}$

(B) $\frac{1}{x}-\frac{1}{y}=\frac{1}{f}$

(C) $xy = f^2$

(D) none of these

69. The distance of an object from the focus of a convex mirror of focal length f is x and the distance of the image from the focus is y. Then

(A) $\frac{1}{y}-\frac{1}{x}=\frac{1}{f}$

(B) $\frac{1}{y}+\frac{1}{x}=\frac{1}{f}$

(C) $xy = f^2$

(D) none of these

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	D	A	A	B	C	B	C	D	C	B	A	B	A	D	C
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	A	A	B	A	A	B	C	D	B	D	D	B	C	D	A
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	B	B	A	C	C	D	D	B	A	A	B	D	A	C	C
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	B	B	A	A	C	C	C	B	C	C	D	C	B	C	A
Que.	61	62	63	64	65	66	67	68	69						
Ans.	A	A,B,D	D	C	A	B	A	C	D						